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Quasars and Pulsars

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Preface

Probably no question has come up more frequently in the question and answer sessions following the presentations of my new physical theory that I have made to college audiences during the past few years than this: *What does your theory say about the quasars?* Of course, as a general physical theory it has a great deal to say about quasars, but unfortunately the observational data on these objects have not heretofore been adequate to enable setting up the kind of a conclusive comparison of theory with observation which would show that what the new theory has to say about the quasars is a correct representation of the facts, and not just another addition to the bumper crop of speculations. Recent developments have improved this situation very materially, and I now feel that the time is ripe to furnish a detailed answer to the perennial question. For good measure, I am throwing in some comments about the pulsars, which are commonly associated with the quasars as the foremost astronomical "mysteries" at the moment.

This should be a particularly appropriate time to demonstrate that there is a physical theory now available which can produce a complete and consistent explanation of all of the newly discovered astronomical phenomena, including the quasars and the pulsars, inasmuch as there is a growing realization in astronomical circles that conventional physical theory has failed to meet the challenge of the new discoveries. As Fred Hoyle recently painted out in a lecture before the Royal Astronomical Society, the total inadequacy of conventional theory in these new areas calls for a "radical revision of the laws of physics." Professor Hoyle's suggestion was that his profession should "stick to the astronomy and force the physics to fit," but this is easier said than done, and it should therefore be of considerable interest to the astronomers to find that there is already a physical theory in existence that fits the new discoveries without having to be forced.

In order that the presentation may be intelligible to those who are not familiar, or not sufficiently familiar, with my previous publications, I am undertaking to trace the development of thought all the way from the concept of a universe of motion, on which the whole theoretical system is based, to the quasar, and to show that once the "motion" concept is substituted for the now untenable concept of a universe of matter, the existence of quasars and pulsars is a necessary consequence a rather distant consequence, to be sure, but an inevitable one. The development of thought will be similar to that in Beyond Newton, except that the subject of that volume, gravitation, is one of the basic phenomena of the universe, and the chain of deductions leading from the fundamental postulates to the conclusions of the work is short, whereas in the case of the quasars it is very long.

This plan of presentation will, of course, require going over some ground that was covered in my previous books, particularly the first in the series, *The Structure of the Physical Universe*; but in view of the fact that a dozen years have passed since that book was written, another look at the situation is no doubt justified. In the meantime I have continued my studies in this area, and I have had the benefit of discussion and correspondence with a great many individuals who are interested in my findings. As a result, I have been able to clarify a number of paints that were previously somewhat hazy, and to devise some further analogies, improvements in terminology, and other aids to understanding of the aspects of the theory that have given the most difficulty to those who have undertaken to follow the logical development.

Very few changes of a substantive nature have been required by reason of the progress made in the last decade surprisingly few, in view of the fact that the original work opened up a whole new field of thought-but there have been some significant changes of and an entirely new concept of the logical basis of the theoretical system has emerged. The general reciprocal relation between space and time is, of course, the key element in the new structure of theory; as I have stressed by calling it the Reciprocal System, and the logical status of this relationship is therefore a matter of prime importance, even though I have established its validity by verifying its consequences rather than relying upon the legitimacy of its antecedents. The reciprocal relation was originally derived from a study of a large amount of empirical data which I analyzed during the inductive phase of the investigation that ultimately led to the development of the new system of theory, and in my first publication I described it as a purely empirical result: an extrapolation from experience. Subsequent studies indicated that the relation was not wholly empirical; that it could be deduced from some elementary considerations with respect to the relation of space to time, and in the later books it was portrayed as a semi-empirical conclusion. Now, after much additional consideration, it has become evident that this reciprocal relation can be derived deductively from the most general kind of premises.

All existing physical theory is based on the assumption that the universe in which we live is a universe of matter, one in which the fundamental entities are "elementary units" of matter existing in a framework provided by space and time. As brought out in the text, this concept is no longer tenable, because many ways are now known in which matter can be transformed into non-matter, and obviously that which can be changed into something else is not basic. There clearly must be some common denominator underlying both of these interconvertible entities. This is not the kind of an issue on which there can be a legitimate difference of opinion. If matter is the basic constituent of the universe, as current theory assumes, then it cannot be changed into anything but some other form of matter. Conversely, if matter can be transformed into non-matter, as we now know that it can, then it is not the basic constituent of the universe, and conventional physical theory is founded on a false assumption. There is no escape from these cold, hard facts.

The "matter" concept must therefore be replaced, and the only alternative in sight is the concept of a universe in which the fundamental entities are units of motion rather than units of matter. A change to the concept of a universe of motion cannot be avoided; at the most, it can only be delayed. The significance of this point, in the present connection, lies in the fact that the reciprocal relation between space and time, on which my new system of theory is based, is a necessary consequence of the "motion" concept. Once this concept of the nature of the universe is accepted, the reciprocal relation follows automatically.

The argument in favor of the Reciprocal System that was presented in my previous publications can be summarized in this manner:

1. Existing theory, in the words of a prominent physicist quoted in this volume, is a "multitude of different parts and pieces that do not fit together very well," and it gives the wrong answers, or no answers at all, to many of the important questions that arise.

2. The Reciprocal System is a fully integrated theoretical structure derived in its entirety from a single set of basic premises, and it is a true and accurate representation of the physical facts in the areas to which it has thus far been applied; hence presumably to all physical areas.

3. It would therefore be highly advantageous to substitute this comprehensive new system of theory for the "multitude of different parts and pieces."

Very few attempts have been made to meet this argument on its merits, but there has been a widespread tendency to object to giving any consideration at all to the new theoretical system on the ground that the a priori probability that a radically new theory might be correct is very low, and that the expenditure of the considerable amount of time and effort required to understand and evaluate it is therefore not justified. Unfortunately, the individual scientists do not ordinarily limit themselves to a refusal to spend their own time on an examination of the new theory, a stand that is hardly open to criticism, at least where there is no official responsibility for the advancement of scientific knowledge; they very commonly object to anyone taking an interest in an unorthodox theory. This constitutes a formidable obstacle that is hard to overcame as long as the point at issue is the relative merit of the two systems of theory.

Recognition of the fact that the real issue is not between two rival theoretical systems, but between two different basic concepts of the nature of the universe changes this picture drastically. Now the question becomes: Shall we stick with a concept that we know is wrong, or should we examine the only alternative in sight? It is futile to sit back and hope that the “matter” concept might somehow be saved. No future advance in observational knowledge or refinement in theory can alter the brutal fact, now so clearly established, that matter is not the basic constituent of the universe. And since even the utmost in logical reasoning cannot derive the right answers from the wrong premises, the present structure of theory, based, as it is, on the “matter” concept, is not, and can never be, a true representation of the physical facts.

This does not mean that all existing physical theories are wrong. Most of these so-called “theories” are actually generalizations of empirical relations between observed phenomena (one of the reasons why present-day theory is a “multitude of different parts and pieces”). Many others are simply mathematical relations that are independent of the theoretical significance that is currently ascribed to them. Still others are essentially nothing more than definitions. “Theories” that fall in these classes, perhaps 90 percent of the present-day total, are not affected by changes in the basic theoretical outlook. But the conclusions that are today drawn from theoretical premises are, of necessity, wrong, because the basic premises are wrong.

The original argument in favor of the new theoretical system is still as valid as ever, but it is now reinforced by a still more powerful argument, inasmuch as there is no longer any question as to whether or not there should be a change in fundamental ideas. When we face the issue squarely it is clear that sooner or later there must be a change.

In as much as this work is addressed to a wide range of scientists who are interested in the physical fundamentals underlying their respective fields of specialization, rather than merely or mainly to astronomers, I have taken as much as possible of the observational data and other reference material from reviews and summaries, principally the book Quasi-Stellar Objects, by Geoffrey and Margaret Burbidge, and a series of articles in the *Scientific American,* rather than referring to the original papers, many of which are not readily accessible to the general reader. In order to avoid confusing the development of thought by introducing a mass of explanatory detail, I have also assumed that any reader who intends to consider the quasar chapters (the last five) in depth will be reasonably familiar with the Burbidges’ work or its equivalent, and will be acquainted with the terminology in which these and other discussions of the quasar phenomena are expressed.

Those who wish to review the developments since the publication of the Burbidge volume can find most of this information in the articles by Maarten Schmidt and G. R. Burbidge in the *Annual Review of Astronomy and Astrophysics* listed in the references. It should be noted, however, that these additional developments do not change the general situation appreciably. As R. J. Weymann points out in one of the *Scientific American* articles, the astronomers “are still groping for some unifying rational picture of all this activity.” The objective of this work is to show that the “unifying rational picture” of the universe as a whole that is derived from the Reciprocal System of theory is a broad panorama that is not limited to the areas close at hand, but gives an equally clear view of far-out phenomena such as those associated with the quasars: phenomena with which conventional theory is unable to cope.

Publication of this new book gives me an opportunity to express my appreciation for the many comments and suggestions that I have received from a host of individuals in all parts of the world. Because of the large volume of correspondence involved, my replies to written communications have not always been as prompt or as complete as one might wish, but I want to assure everyone concerned that this assistance has been very helpful, and it has had a profound influence on the direction that my publication efforts have taken.

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D. B. Larson

CHAPTER I

Introduction

In 1950 radiation at radio frequencies originating in M 31, the big spiral galaxy in Andromeda, was detected at the Jodrell Bank Observatory by Hanbury Brown and Hazard. This, the first observation of radio emission from a definitely identified extragalactic source, was an interesting and important event in itself, but it had a far greater significance that was not realized at the time, for it was the first step in a series of developments that have completely revolutionized the astronomy of the extra-galactic regions. Probably no sub-division of human knowledge has ever before had the experience of making so many surprising and dramatic discoveries in so short a time.

The radio emission from the Andromeda galaxy is very similar to that which originates within our own galaxy, and it raised no new issues of a major character, but in 1951 a very much stronger radio source, Cygnus A, was identified with a faint galaxy which, as nearly as can be determined, is about 700 million light-years distant, more than 300 times as far away as the Andromeda spiral. In order to transmit so much energy over such a stupendous distance the source must be enormously powerful, and the astronomical community thus came face to face with the first of the bafHing new problems: How could such an enormous amount of energy be generated?

The situation as it stood in 1960 was summed up by Steinberg and Lequeux in these words: “The problem posed by the existence of these radio galaxies is one of the most mysterious in the universe. . . . At the present time, according to all appearances, we Iack even the most elementary foundations for constructing a theory of extragalactic radio sources.”1

The next ten years after the identification of the first radio galaxy saw a gradual improvement of radio astronomy equipment and techniques, and this, in turn, resulted in a relatively rapid increase in the supply of information from observation. Thousands of discrete radio sources were detected and located with a constantly increasing precision. Optical identification of these sources is a difficult undertaking and proceeded more slowly, but both the number and the accuracy of these identifications grew steadily. A particularly significant finding during this period was that a very substantial number of the radio galaxies have two centers of radio emission located on opposite sides of the galaxy. This suggested the possibility of explosive ejection, and in 1962 A. R. Sandage of Palomar and C. R. Lynds at Lick Observatory were able to secure optical evidence of an explosion that had apparently taken place some two million years ago in the galaxy M 82.

Here was a most spectacular discovery: an event millions, perhaps billions, of times more energetic than anything ever before detected anywhere in the universe. But this did not solve the problem of the radio galaxies; it merely deepened the mystery. "Even at this early stage of inquiry we find that radical new ideas are needed to account for the enormous energies involved in these events," reported Sandage, and he ivent on to say, "It is obvious that conventional energy sources are not adequate to explain the phenomenon we are observing, and some totally new energy principle may have to be devised."2

Even as these words were being written, the next chapter in the mystery was already unfolding. Sandage himself had previously discovered a strange object, designated 3C 48, a strong radio source that appeared to be a star, but had a spectrum quite different from that of any known star. In 1963 another similar object, 3C 273, was discovered, and this one was located very accurately by Hazard and co-workers in Australia. A careful study of the 3C 273 spectrum by Maarten Schmidt of Palomar then revealed that the spectral lines were shifted 16 percent toward the red. A restudy of the 3C 48 spectrum subsequently found a similar, but even greater redshift.

The frequencies of the light from all of the distant galaxies are shifted toward the red in this manner, and the only explanation for the shift that has stood up under critical scrutiny is that it is a Doppler effect due to motion of the source of the emission, similar to the change in pitch of the whistle of a receding locomotive. The redshift of the galaxies whose distance from the earth can be estimated by one means or another has been found to increase in direct proportion to the distance; that is, so far as can be determined at this time, these galaxies are moving outward away from us at tremendous speeds, and are moving faster and faster as they get farther away. We may thus infer the distance of a galaxy or other luminous object from its redshift, and if the same relations are applicable to 3G 48, the 37 percent shift in the spectrum of this "quasi-stellar" radio source indicates that it is among the most distant objects that have thus far been observed, billions of light years out in space. But in that event, this comparatively small object and others of its kind must be emitting more energy than dozens of the largest and brightest galaxies combined.

Again a big step forward has been taken in the observational field and a significant addition to astronomical knowledge has been made, but once more the mystery has only deepened. The existence of these QSS, quasi-stellar sources, or quasars, has not explained the galactic explosions or the radio galaxies. On the contrary, it has merely added another dimension to the mystery; it has supplied a new set of unexplained and seemingly inexplicable facts. This 1963 statement by Jesse Greenstein may still be regarded as the current assessment of the situation:

In any event, we have encountered a most baffling group of astronomical objects. Whether fundamental new processes lie behind their brilliant but ephemeral appearance, or whether our imaginations are still too limited, remains for the future to determine.3

But there was actually no need to leave this determination to the future. During all of the time that these spectacular advances in observational knowledge were being made by the astronomers without any semblance of a theoretical understanding of the phenomena they were observing, a logical and consistent theory of these phenomena was available, having been developed in total isolation from the men in the observatories, entirely independent, and generally far in advance, of the observational discoveries. As early as 1959, long before the first observations of an exploding galaxy were made at Palomar, the first book in this present series advanced a new explanation of the structure of matter, and showed that on this basis the atoms of matter were subject to certain limits, the attainment of which would cause the atomic mass to revert to kinetic energy. One of these limits, it was demonstrated, is reached in the interiors of the oldest and largest galaxies, hence at a certain stage of its existence a substantial portion of the mass of such a galaxy is transformed into energy, giving rise to exactly the kind of a phenomenon observed by the astronomers.

A further development of the theory revealed that the explosions of this nature would necessarily be accompanied by radiation of substantial amounts of energy at radio wavelengths, and the 1959 publication predicted that radio astranomy would be the most probable avenue through which these exploding galaxies would be located. The general characteristics of the explosion products were also predicted, with special emphasis on the point that these products would be of two distinct kinds, one quite normal in the material environment and the other highly abnormal.

At that time it did not seem advisable to extend the study of these unknown phenomena into any great detail, inasmuch as this was only one relatively small portion of the total field that was being covered by the investigation. Thus the preliminary results did not by any means exhaust the potentialities of the new theoretical approach to this explosion phenomenon, and now that the predictions have become observed realities, the same theory that foresaw the existence of these phenomena is available to explain the observations and to clear up the details and relations that are the occasion for the frequent use of the term “mystery.” On the basis of this new system of theory, the quasars are not freaks or incidental phenomena; they are directly in the main line of the cyclical process that constitutes the fundamental action of the universe, and both their existence and their properties can be derived theoretically from nothing more than the postulated properties of space and time.

There is, of course, a general reluctance to accept any such farreaching revision of scientific thought as that required by this theory. As the quotations in the earlier paragraphs indicate, the astronomers have recognized that some drastic modifications of existing ideas will probably be necessary, some “radical new ideas” or “fundamental new processes,” and the physicists, who have as their field of endeavor the basic principles of those phenomena that the astronomers observe on the grand scale, are no less candid concerning the status of those basic principles. “There will have to be some new development,” says P. A. M. Dirac, “that is quite unexpected, that we cannot even make a guess about."4 But the individual who is quite willing to accept the necessity of radical new ideas as an abstract proposition, and even to proclaim their inevitability, usually takes a very different attitude toward any concrete new ideas. The abstract concept of a change in fundamental thinking is quite innocuous. The individual scientist can cheerfully accept the prospect of such a change, secure in his confidence that his own cherished ideas are so firmly grounded that they will not be affected. But any concrete proposal for a change in fundamentals necessarily comes in conflict with some of these strongly held beliefs, and it consequently meets immediate hostility.

The attitude of the astronomers toward the new structure of theory that is here being discussed is no exception to this rule. This theory is the equivalent, from the astronomical standpoint, of a new instrument of exceptional power and versatility; that is, it produces a detailed picture of the astronomical universe from purely theoretical sources, completely independent of any information derived from observations, and it should be particularly welcome because it is not subject to the inherent limitations of physical instruments. But the more powerful the instrument the more errors it finds in currently accepted beliefs, and astronomers, like other members of the human race, dislike changes in long-standing patterns of thought. While they talk bravely of "radical new ideas" they do not actually want anything of the kind. What they want is some sort of a magic formula that will solve their problems and explain the galactic explosions, the radio galaxies, the quasars, etc., without having any radical effect on anything else, without affecting current astronomical thought in other areas. They are not favorably disposed toward any solution of those problems which, like the one that will be described herein, involves major changes in the theoretical outlook elsewhere in astronomy: in the processes of energy generation in the stars, the course of stellar evolution, the process af formation of galaxies, etc. So the gap has remained; on the one side a series of problems without answers; on the other side the answers to the problems, but no means of getting them into service.

After more than a decade, a break, or at least a crack, in the wall separating these problems from their answers has finally occurred. It is difficult to find a qualitative test that will decide between existing theory and a challenger, or between any two theories, because it is nearly always possible to make further assumptions that will sidestep any qualitative difficulties that a theory may encounter. For this reason, a final decision is not ordinarily possible until some conclusive quantitative information becomes available. The event that has stimulated the preparation of this present volume is the appearance of some new information of the necessary character. Studies by Halton Arp of the Mount Wilson and Palomar Observatories have disclosed that some of the quasars are apparently associated with "peculiar" galaxies that show evidence of having been subject to violent processes of some kind, explosions such as those previously mentioned, or other events involving the release of huge amounts of energy. Arp finds that in many cases a pair of radio sources, generally radio galaxies or quasars, are lacated on opposite sides of one of these "peculiar" galaxies and approximately in line. His conclusion is that the two radio sources have been ejected from the exploding galaxy at some earlier time and have moved out to their present locations in the interim.

Here we have an opportunity to apply the new theoretical system to an aspect of the quasar situation that is complex enough to require a full scale theoretical treatment. There is wide latitude for the constructon of ad hoc theories of the quasars alone, or the radio galaxies by themselves, or the galactic explosions as isolated phenomena, and a fantastic assortment of “super-stars,” “quarks,” and the like, has emerged from the theorists speculations. But the more we find out about a subject the less room there is for speculation. As Harlow Shapley remarked about theories of the origin of the universe,

Facts have been the No. 1 enemy of cosmogonic theories. If we did not know sa much, we would have less to explain.5

Specific mathematical relations are particularly effective in restraining the theorists flights of fantasy, and if Arp‘s conclusions are correct some mathematical consequences necessarily follow that are incompatible with all existing ideas as to the nature of the quasars, while they are in full agreement with the values calculated on the basis of the new system of theory. Inasmuch as this theory also produces a complete qualitative explanation of the quasars and associated phenomena-the galactic explosions, the supernovae, the white dwarfs, the pulsars, etc: it would seem that the time has come to brush away the theoretical cobwebs and take a fresh view of the universe in which we live.

Although the primary objective of the presentation in this volume is to demonstrate that the new structure of theory herein outlined produces a full qualitative explanation of the existence and properties of the quasars, and is in complete agreement with the quantitative results obtained from an analysis of Dr. Arp‘s findings, results that are inexplicable on the basis of current quasar theories, the theoretical development will, as just mentioned, have a significant bearing on a number of additional phenomena that are to some degree associated with the quasars. Inasmuch as one of these associates is equally as mysterious, to the astronomers, as the quasars, and even more recently arrived on the scene, it will be appropriate to consider the information that can be derived from the theory with respect to this new arrival, the pulsar, and to compare the theoretical conclusions with the rather meager amount of observational data thus far accumulated.

The first of the objects naw known as pulsars was discovered in 1967 by a group of astronomers at Cambridge who were undertaking a special survey of the quasars. The pulsars emit radiation at radio wavelengths, which explains why they were found unexpectedly in a quasar survey, and their special characteristic is that most of the radiation is received in the form of regular pulses. Each pulsar has its own pulse interval, which is subject to some occasional short term variations and a gradual lengthening with time, but otherwise is surprisingly constant. The longest interval thus far measured is 3.5 seconds and the shortest .033 second, the latter being the measurement abtained for the pulsar NP 0532, which is located in the center of the Crab Nebula, a point that has an important theoretical significance, as we will see when we undertake a theoretical examination of the pulsars later in the work. A pulse of approximately the same period has been found in both the optical and the x-ray radiation from a star that has been identified with NP 0532.

Like the quasars, the pulsars simply do not fit into the existing structure of astronomical theory, and the workers in the field find it hard even to speculate about these objects without invoking fantastic concepts such as “neutron stars” or “gravitational collapse ” , purely ad hoc constructions that are essentially equivalent, in all but the language in which they are expressed, to the spirits and demons of the pre-scientific age. The status of the attempts to account for the observed properties of the pulsars on the basis of current astronomical thought was summed up by H. Chiu of the Goddard Space Flight Center at a symposium on the Crab Nebula in June 1969 in these words:

The nature of the pulsars is perhaps one of the most perplexing astrophysical problems of this centurya.6

CHAPTER II

Design of the Universe

It is generally conceded by those who are in close touch with the situation along the frontiers of physical knowledge that the existing body of physical theory is far from satisfactory. As expressed by Richard Feynman:

Today our theories of physics, the laws of physics, are a multitude of different parts and pieces that da not fit together very well. . . . We have all these nice principles and known facts, but we are in some kind of trouble.7

Now, why are we in trouble? The truth is that the root of the difficulty is quite generally recognized by those wha are on the firing line. The principal obstacle that stands in the way of constructing a more adequate theory of the physical universe is that modern science has not been able to determine just what kind of a thing it is dealing with. Before we can construct an accurate theory of anything we must have at least a reasonably good idea as ta the nature of the thing about which we are theorizing. This, physical science does not now have.

For the first hundred thousand years or so of the existence of the human race, the prevailing concept was that of a universe of spirits. The ultimate realities, according to this point of view, are not the physical objects but the demons and spirits that inhabit and control those objects. This “spirit” concept is not entirely dead even today, but the ancient Greeks arrived at a realization that it was not adequate to deal with the new knowledge that they were accumulating in their pioneer efforts along the line of what we now call science, and they initiated a change in thinking that ultimately resulted in the replacement of the concept of a universe of spirits by the concept of a universe of matter: a universe in which the basic entities are elementary particles of matter existing in a setting or background provided by space and time. This is the concept that underlies all of our present-day physical science.

Science was engaged in sketching, bit by bit, the plan of a machine-a gigantic machine identical with the universe. According to the vision thus unfolded, every existing thing was matter, and every piece of matter was a working part of the cosmic technology. (Jacques Barzun) 8

Today we are back in the same kind of a situation that confronted Aristotle and his contemporaries. The prevailing concept of the nature of the universe has broken down. Although the fact is not yet generally recognized, mainly because no one wants to face the issue, the “matter” concept of the universe has been completely demolished by the modern discovery that matter can be transformed into nonmatter, and vice versa. In the "annihilation" reaction between the electron and the positron, for example, these twa particles, which are recognized as material, inasmuch as they possess mass and other material properties, are completely converted into radiation, which is not matter. Obviously, the demonstrated interconvertability of matter and non-matter is conclusive proof that matter is not basic. There must be some common denominator underlying both matter and non-matter. However reluctant scientists may be to part with it, the concept of a universe of matter is no longer tenable, and sooner or later it will have to be abandoned, along with those portions of existing theory that are wholly dependent on this concept.

Since we are in trouble, and we know why, the next question that arises is: What are we going to do about it? What can be put in the place of this erroneous concept of a universe of matter? Oddly enough, the most likely answer to this question has been known for centuries. It has long been realized that some very substantial advantages would accrue from replacing the "matter" concept with the concept of a universe of motion: one in which the basic entities are units of motion rather than units of matter.

As sa many previous investigators have observed, a physical theory based on the "motion" concept could be comprehensive; that is, it could embrace such items as radiation and electrical phenomena which are an acute embarrassment for the present-day "matter" theories, inasmuch as they are neither matter nor part of the background in which matter is presumed to exist. Furthermore, a theory based on the "motion" concept could account for the behavior of physical entities as well as for their existence. When we formulate a theory or a set of theories to explain the existence of such entities on the "matter" basis, we must construct another set of theories to explain how they behave, but a theory based on the "motion" concept can explain not only what these entities are but also what they do. It is beginning to be suspected that modern physical discoveries will force the development of comprehensive theories of this nature. K. W. Ford makes this comment:

There are some new hints that open up one of the most challenging prospects in modern physics, hints that perhaps we are approaching a merger of the description of events and the description of things-that the theory of the behavior of the particles and the theory of the structure and nature of the particles may prove to be one and the same thing.9
The "motion" concept can give us this kind of a merger; the present "matter" concept cannot. Then, too, the "motion" concept brings us appreciably closer to an ultimate understanding of the physical universe. If we postulate a universe of matter, we are immediately confronted with the question, What is matter?, a question that has never been fully or satisfactorily answered. But we think that we have an intuitive understanding of what motion is.

So we are in trouble, we know why, and we know the most promising way out of our difficulties. Why, then, is there no available structure of theory based on the "motion" concept? The answer is that hundreds of years of painstaking effort by competent scientists and philosophers-such men as Eddington, Hobbes, and Descartes, as well as a multitude of less prominent individuals-have been unsuccessful, and no workable theory of a universe of motion has heretofore been constructed. These previous investigators have started with the fundamental premise of the "motion" concept, the premise that we live in a universe of motion-“all things have but one universal cause, which is motion,” says Hobbes unequivocally-and have attempted to build upon this foundation, but they have invariably encountered an obstacle which they have been unable to surmount, or even to identify, and their most strenuous efforts have been fruitless.

The key that finally opened the door to the construction of an accurate and comprehensive physical theory based on the “motion” concept was the identification of the obstacle that blocked the efforts of these previous investigators. The reason why they all arrived at a dead end before they advanced very far, we now find, is that they all failed to realize that switching from a universe of matter to a universe of motion requires a change in the definition of space and time. The usual definition of matter, as employed in present-day physical science, does not define space and time. Consequently, when we specify that matter is the basic constituent of the universe we must define space and time independently. This is what has been done. In the absence of any factual information on the subject, some assumptions have been made, based mostly on the impressions of space and time gained from casual observation, and the definitions have been set up accordingly. There is much difference of opinion regarding the details, particularly with respect to space-whether or not space is absolute and immovable, whether such a thing as empty space is possible, whether space and time are interconnected, and so on-but the essential thought has remained the same: space and time, as seen by scientists and laymen alike, are the setting or background in which physical phenomena take place.

While fields and particles come and go, space and time lie inert, providing the stage upon which the actors play their roles. (K. W. Ford) 10

But when we specify that the basic constituent of the universe is motion, we can no longer set up independent definitions of space and time in this manner, because in defining motion we are also, at the same time and by the same act, defining space and time. Motion is defined as a relation between space and time, and is measured as speed or velocity, the mathematical expression of that relation. The equation o f motion in its simplest form is v = s~t. As can be seen from this equation, the standard definition of motion in terms of space and time is also a definition of space and time in terms of motion; that is, in motion, space and time are the two reciprocal aspects of that motion, *and nothing else.*

In a universe of matter, the fact that space and time have only this limited significance with respect to motion does not preclude them from possessing other aspects in connection with phenomena of a different character, as present-day theory assumes that they do. But in a universe of motion, where all physical entities and phenomena are manifestations of motion, the role of space and time in motion is their role in the universe as a whole. Since there is nothing but motion, they cannot have any properties or any significance that they do not have in motion. In particular, they cannot constitute a setting or background for motion, because motion is not a background for itself. Everywhere in a universe of motion, space and time are the two reciprocal aspects of that motion, and they have no other significance anywhere.

This is where the previous investigators made the mistake that prevented them from accomplishing their objectives. To Eddington and the other early adherents of the "motion" concept, the units of motion that would take the place of particles of matter as the ultimate constituents of the universe would still be located in the same kind of a space-time framework that formed the background for the hypothetical universe of matter, and they were unable to see that this is incompatible with their definition of motion. It is interesting to note that some of these investigators did actually reach the point of realizing that the conventional views of the relations between space, time, and motion would have to be modified. Eddington's views were influenced rather strongly by those of one of his predecessors, W. K. Clifford, and he noted that "Clifford was convinced that matter and the motion of matter were aspects of space-curvature and nothing more:" Here we see a recognition of the fact that going to the concept of a universe of motion requires a direct and intimate connection between space, time, and motion rather than the independence that exists in the "matter" universe, but Clifford and Eddington were still unable to get entirely away from the concept of space as a container or setting for physical events-something that could be "curved."

When we finally do make a clean break with the "matter" concept, and accept the definition of space and time that is required by the concept of a universe of motion, the first consequence that we note is that on the basis of this "motion" concept there is a *general reciprocal relation between space and time*. Here is an idea that is manifestly absurd in the context of the prevailing pattern of thought. In the light of currently accepted views of the nature of things, the reciprocal of space is simply inconceivable. But the truth is that these accepted views are simply creatures of the "matter" concept. When it is postulated that the ultimate constituents of the universe are "elementary units" of matter, then there must be a setting or framework in which this matter exists, and it has been assumed that space and time constitute such a framework. Current ideas as to the nature of space and time are thus dictated by the prevailing concept of the kind of a universe with which we are dealing. When we replace the "matter" concept with the concept of a universe of motion, and as a consequence find that we must redefine space and time as simply the two reciprocal aspects of motion, that which was previously inconceivable now becomes inevitable. In speed, the measure of motion, more space is the equivalent of less time and vice versa.

Furthermore, this is not merely a mathematical relation; it is a general relation. The equation $v = s/t$, which says that the speed is equal to space divided by time, could equally well be written in the reciprocal form, which would assert that the reciprocal speed is equal to time divided by space. Either of these two forms is equally as valid a representation af the relationship as the other-there is nothing in the definition of motion that can distinguish between the two -and it is thus evident that space and time are similar entities, differing only in that they stand in a reciprocal relation to each other. Any property that may apply to one likewise applies, in the reciprocal form, to the other.

At first glance, this statement may seem to be a direct contradiction of experience, as the observed properties of space do not resemble the observed properties of time at all. But we will find as we proceed with the theoretical development that these differences in the way in which space and time appear under observation are not due to any actual dissimilarity between the two, but are a result of our particular position in the universe, which gives us a different view of one than of the other. For example, time appears to be essentially a progression, whereas space seems to “stay put,” but we will find that our view of space is distorted by our special position, and that space actually progresses in the same manner as time.

Likewise, we recognize three dimensions of space, but time appears to be one-dimensional: a linear progression from the past to the present and on into the future. This view of time seems to be confirmed by the equations of motion, such as v = s/t, in which s is a vector quantity while t is a scalar quantity. But the one-dimensionality does not, in fact, follow from the scalar character of the term. What current thought has overlooked is that speed or velocity in the context of present-day usage always refers to speed or velocity in space (the existence of motion in time is not recognized at all) , and the equations as ordinarily expressed are therefore space velocity equations. In such an equation any term representing time is necessarily scalar, irrespective of how many dimensions time may have, inasmuch as time has na s~atial dimensions. Whatever dimensions it has are dimensions of time, not dimensions of space. The scalar nature of the time term thus has no implications with respect to the dimensions of time. The fact that we are able to observe only one time dimension likewise does not preclude the existence of other dimensions that are not directly observable.

We are thus on sound ground in postulating that motion is three dimensional. This is the first of a few assumptions that we will have to make about the properties of space and time, in their capacity as aspects of motion, in order to complete the foundations for a general physical theory based on the concept of a universe of motion. Only one more physical assumption is required: the assumption that motion, and hence space and time, exist only in discrete units. As already pointed out, the “motion” concept itself establishes a reciprocal relation between space and time. Together with three assumptions as to the mathematical behavior of the universe, the foregoing items constitute the Fundamental Postulates of the new system of theory, the Reciprocal System, as it has been named, because of the key position of the reciprocal space-time relation in the theoretical structure.

From these postulates as premises, the entire structure of theory has been developed deductively, without introducing any further assumptions of any kind, and without the use of any information derived from observation. In the case of the objects that are the principal subjects of the discussion in this present volume, the quasars and the pulsars, both the existence and the properties of these objects have been derived theoretically from the postulated properties of space and time, and from these properties only, without resort to assistance from any other source. The postulates may be expressed as follows:

First Fundamental Postulate: The physical universe is composed entirely of one component, motion, existing in three dimensions, in discrete units, and with two reciprocal aspects, space and time.

Second Fundamental Postulate: The physical universe conforms to the relations of ordinary commutative mathematics, its magnitudes are absolute, and its geometry is Euclidean.

The objective of the presentation in the pages that follow will be to demonstrate that the quasars, the pulsars, and the astronomical phenomena with which they are associated are implicit in these postulates.

From the very first, a question has existed as to the terminology in which the postulates should be expressed; specifically, whether the basic constituent of the universe should be called "space-time" or "motion." The original conclusion, as stated in *New Light on Space and Time*, was in favor of using the term "space-time":

It seems advisable to select those terms which will be most understandable in the context of existing thought and which will facilitate explaining the new theoretical structure to individuals who are familiar with previously accepted ideas. We will therefore say that the universe has only one component, and for the present, we will call this component space-time, with the understanding that this term is equivalent to motion, when motion is taken in the most general sense.

In the meantime, additional experience, both in the clarification of the details of the theory, and in the presentation of the theory to college audiences, has indicated the desirability of laying more emphasis on motion, and the wording of the First Postulate has been changed accordingly. No change in the substance of the postulate is involved.

One of the factors that enters into this situation is a widespread inability to conceive of the existence of motion which is not motion of anything, the kind of basic motion that is synonymous with spacetime. A major reason for reversing the original decision with respect to terminology and replacing "space-time" with "motion" is that it is absolutely essential, for an understanding of the theoretical development, to recognize that the relation between space and time that is represented by the expression "space-time" is a motion, not, as current theory assumes, some kind of a super-space in which time plays a quasi-spatial role. *Any* relation between space and time is motion.

Many individuals are very emphatic in the assertion that motion is necessarily motion of something, and that anything else is impossible. But those who are so positive on this score are laying down a principle that is valid only in application to a universe of matter, and has no place in a universe of motion. If the basic entities of the universe are material "things," and motion is a property of those "things" then, of course, the objectors are correct; matter is logically prior to motion, and there can be no motion that is not motion of something. But if this is a universe of motion, in which matter is a complex of motions, then motion is logically prior to matter, and there must be simple motions before there can be matter or motion of matter. Hence the existence of these simple motions is not only logical but essential in a universe of motion. It should be noted, in this connection, that the mathematics of motion of matter are equally applicable to the simple motions, since an equation such as $v = s/t$ has no term representing the "something" even if it refers to a motion of something.

Many other features of the new theoretical system will no doubt seem strange, perhaps even incredible, on first consideration, but it should be realized that this initial reaction is a result of trying to fit the new ideas into the pattern of existing thought, a pattern that is based on the "matter" concept, whereas in order to arrive at an understanding of the theory it is necessary to view each of the details in the context of the "motion" concept. This will require a certain amount of mental reorientation, to be sure, but it is hardly possible to make a significant advance in physical understanding without upsetting some previous beliefs, and the greater the advance the more dislocation of existing thought will be required.

It should also be realized that the development described herein is unprecedented in that it is *wholly* theoretical. All previous physical laws and theories are composite structures that include empirical as well as purely theoretical elements. The theorist *begins* with observed facts, and the nature of his activities has been described in this manner:

Faced with the facts of physical observation and experiment, the theoretical physicist applies the abstract relationships of mathematics to connect these facts and predict new facts.12

The "matter" that enters into Newton's law of gravitation is one of these "facts of physical observation," not a theoretically defined entity. It is the matter that is actually encountered in the physical world, an entity whose precise nature is still a subject of considerable difference of opinion. Similarly, the photon of light that enters into the theory of the photoelectric effect and various optical relations is not a theoretically defined entity; it is an observed phenomenon whose real nature is understood only vaguely. This mingling of theory and observation cannot be avoided as long as physical science is still in the stage where a great many observed phenomena must be treated as unanalyzable, and hence it has come to be regarded as a characteristic of all theories. It is important to note, therefore, that the Reciprocal System is not a composite theory of the usual type; it is a purely theoretical structure that includes nothing of an empirical nature.

For example, the "space" with which this system deals is not physical space; it is theoretical space. Of course, the exact correspondence between the theoretical and observed universes that will be demonstrated in the course of the development means that the theoretical space is a true and accurate representation of the actual physical space, but it is important to realize that what we are dealing with *in the development of theory* is the theoretical entity, not the physical entity. The significance of this point is that while physical "space," like "matter" and other physical items, cannot be defined with precision and certainty, as there can be no assurance that our observations give us the complete picture, we do know *exactly* what we are dealing with when we talk about theoretical space. Here, there is no uncertainty whatever. Theoretical space is just what we have defined it to be-no more, no less.

The same is true of all of the items that enter into the subsequent theoretical development. Inasmuch as the basic elements of the theoretical system are explicitly defined, and their consequences are deduced by sound logical and mathematical processes, the conclusions that are reached are unequivocal. Of course, there is always a possibility that some error may have been made in the chain of deductions, particularly if it is a very long chain, but aside from this possibility, which is at a minimum in the early stages of the development, there is no question as to the true nature and characteristics of any theoretical entity or phenomenon that emerges.

Unlike Newton, who was unable to determine *why* the matter that he observed conformed to the gravitational law that he formulated, we know exactly why our theoretical atom of matter gravitates. There is no doubt as to either the structure or the properties of this theoretical atom, because both are consequences that we are able to derive from our basic assumptions as to the properties of space and time. Such certainty is impossible in the case of any theory that contains empirical elements. The currently popular theory of the atom has undergone a long series of changes since the time that it was first formulated by Bohr and Rutherfard, and there is no assurance that the modifications are at an end. On the contrary, a general recognition of the weaknesses of the theory as it now stands has stimulated an intensive search for ways and means of bringing it into a closer correspondence with reality, and current literature is full of proposals for revision.

Theories of this kind are particularly vulnerable to what we may call involuntary changes, modifications that are not initiated by efforts to improve the theory, but are forced by reason of new experimental or observational discoveries. The purely theoretical Reciprocal System, on the other hand, contains no empirical elements, and it is therefore unaffected by any change in empirical knowledge. This is a point that should be clearly understood before any attempt is made to follow the development of theory in the subsequent pages. The theory therein described is a single integrated unit that stands or falls as a whole. It is not subject to any change or adjustment, other than the correction of any errors that have been made, and addition of new items due to the extension of the theory into other areas. Once the postulates have been stated, the entire character of the resulting theoretical universe has been defined, down to the most minute detail.

Just because of the postulated properties *of space and time* a theoretical entity that has the same properties as the observed entity known as matter must exist, and this theoretical matter must exist in the form of atoms. Because of the postulated properties *of space and time* there must be different kinds of atoms, and these different kinds must form a series in which each member, or element, differs from the one preceding by a single unit of motion. Because of the postulated properties *of space and time* the theoretical elements must have certain characteristics that divide the series into groups. Because of the postulated properties *of space and time* each theoretical element must have certain physical properties, the magnitudes of which are characteristic of the particular element and can be calculated from the basic factors that apply to each element by virtue of its position in the atomic series and group. Because of the postulated properties of sfiace and time each theoretical element must be able to combine in certain specific ways with certain other elements, and these theoretical combinations, or compounds, must have specific properties of the same nature as those appertaining to the individual elements, and capable of being calculated in a similar manner.

For the purposes of this present volume it will not be necessary to carry the discussion of matter and its properties beyond the point of establishing the nature of the atomic structure and the limitations to which it is subject. Similarly, our consideration of other physical areas-radiation, electrical and magnetic phenomena, radioactivity, etc: will be limited to those issues that have a direct bearing on the specific objective of this work, but it should be understood that in each of these areas the development of the consequences of the postulated properties *of space and time* produces an exact theoretical counterpart of the observed pattern of phenomena in the area, just as it does in the case of the properties of matter.

Furthermore, the theoretical behavior of large aggregates of matter is determined by these same basic postulates. The postulated properties *of space and time* account for the existence of theoretical stars, star clusters, and galaxies, for theoretical pulsars and quasars, and for the interrelations between these and other features of the theoretical astronomical universe. The same properties of space and time that determine the structure of the smallest theoretical atom also determine the structure of the largest theoretical galaxy. Thus there is no leeway for adjustment or modification anywhere in the system. The theoretical universe, all the way from atom to galaxy and from photon to quasar, is specifically defined by the basic postulates.

Of course, if this theoretical universe were only a completely integrated, self-consistent theoretical system, and nothing more than this, it would be merely an interesting intellectual exercise, similar to some of the more abstruse systems of mathematics or geometry that have engaged the attention of the mathematicians in recent years. But there is one very important fact that gives the theoretical universe an altogether different significance. The features of this universe derived from theory have been checked against the corresponding features of the observed physical universe in thousands of separate cases in many different physical fields, and in no instance has there been any conflict. Wherever sufficient observational or experimental information has been available to enable a meaningful comparison to be made, there has been agreement, or at least no inconsistency. In total, these comparisons have been numerous enough and diversified enough to reduce the probability of a conflict between the two systems in any respect to a negligible level, thereby justifying the assertion that the theoretical universe of the Reciprocal System is a true and accurate representation of the actual physical universe.

Because of their semi-empirical nature, the general run of physical theories cannot be used with any degree of confidence outside the range for which they have been specifically verified. Extrapolation into other areas may give the right results, or it may not; it is always risky. Thus the area of coverage of these theories is essentially coextensive with the range of the observational facilities. The big advantage of an accurate and potentially complete picture of the universe such as that supplied by the Reciprocal System is that it is not subject to these limitations. This theoretical picture not only gives us a clear view of those situations in which the observational data are inadequate and confusing-particle physics, for example-but also reveals the existence of significant features of the universe, such as the progression of space, that have not hitherto been recognized at all.

Much of what the new theoretical system has to offer is still a potentiality rather than a finished product. The answers that it is capable of furnishing do not come automatically; tracing out the detailed consequences of the basic postulates requires a great deal of careful and painstaking work, and a long period of investigation and study lies ahead. But because the theoretical development is completely independent of any data from observation, the theoretical conclusions regarding the areas that are observationally unknown, or only partially known, can be just as accurate as those that refex ta well-known phenomena. This can appropriately be compared to the coverage of an aerial map, which portrays the geographical features of an area inaccessible to sur£ace exploration just as accurately as the features of the accessible areas. Absence of the limitations to which observations are subject is especially signi&cant when we undertake to examine the theoretical status of such objects as quasars and pulsars.

CHAPTER III

Simple Linear Motion

The basic premise of this work, as explained in Chapter II, is that the physical universe is a universe of motion. The task of constructing a comprehensive theory of this universe, from which we can derive an explanation of the quasars and the pulsars, therefore reduces to nothing more than determining just what kinds of motion are possible, and what changes from one to another can take place under what circumstances. As a base from which to start, we have expressed the general characteristics of the motion in the form of two fundamental postulates, and from this point on we will simply be developing the necessary consequences of those postulates.

In beginning this development, we note first that motion, as defined for the purposes of these postulates, is inherently a progression. This is consistent with the usual textbook definition of motion which uses the expression “continuous change,” or its equivalent, but we are utilizing the term “progression” to emphasize the fact that although motion exists only in discrete units, it is a continuous process, not a series of jumps. A unit of motion is a specific section of the *progression*, and there is progression even within that unit, simply because this is the nature of the entity; the unit is a unit of progression.

Since time is merely one aspect of motion, it, too, progresses. In dealing with this progression it will be convenient to introduce the concept of *location*. Any designated portion of the time progression, the size of which will vary with the circumstances, is a location in time. In common usage such a location is identified by reference to an arbitrary datum and is expressed in a form such as 1492 A.D. Now let us anticipate the subsequent development to the extent of recognizing that this development will reveal the existence in the physical universe of certain specific physical entities which, for present purposes, we will call “objects.” If such an object existed at time *location* 1492 A.D. and had no mechanism whereby it could change its position relative to time, we recognize that 100 years Iater the object would no longer be found at 1492 A.D., but would exist at a different time location, 1592 A.D. This, then, is one concept of time location. But if we look at the situation from another standpoint, it is obvious that any object which has no independent motion must remain at the same location. Thus we have here another concept of location, which we will call *absolute lacation*. As a general principle we may say that any object which has no independent motion with respect to time remains at the same absolute location in time and is carried forward by the time progression.

The situation is similar to that of a boat on a river. We may specify the position of such a boat in either of two ways. First, we may locate it with reference to some point or points on the river bank. This we will call its *coordinate location*, as where accuracy is desired a system of coordinates will normally be utilized. Alternatively, we may specify the location of the boat with respect to the stream, the absolute location, as we have just defined it. If the boat is without power it remains permanently in the same absolute location, the same position in the stream, and in that case its change of coordinate location is determined entirely by the rate of stream flow, not by any property of the boat itself. If the boat is in motion under its own power, the change of coordinate location is the net resultant of the stream flow and the movement of the boat relative to the stream.

By reason of the reciprocal relation between space and time all that has been said about time in the preceding discussion is equally applicable to space. Space, like time, is an aspect of motion, and like time, it progresses. Here, too, an object which has no independent motion with respect to space remains at the same absolute space location, and is carried along by the space progression. As it happens, most of the familiar objects of our everyday experience do have independent motions with respect to space, and for this reason the existence of the space progression has not heretofore been recognized, but there is ample evidence of its existence, as we will see shortly.

Another consequence of the reciprocal relation between space and time is that each individual unit of space is equivalent to an individual unit of time. In primitive or undifferentiated motion, therefore, the progression of space and the progression of time take place coincidentally. For some purposes it will be convenient to regard this basic motion as a joint progression, a progression of space-time, motion in its most general form. This progression takes place uniformly, because each unit of space (or time) is equivalent to any unit of time (or space) , and consequently all units of space (or time) are alike. It takes place at unit speed, one unit of space per unit of time, and *outward*, because increasing space accompanies increasing time. Any object which has no independent motion with respect to either space or time remains in the same absolute space-time location.

Those who have difficulty in conceiving of motion that is not motion of something may find it helpful to regard the progression of space-time as motion of the absolute reference system, the natural reference system to which the physical universe conforms, with respect to the stationary coordinate reference system that we recognize in our daily Iife. This is analogous ta the motion of the stream, the reference system for floating objects, with respect to the river bank, the reference system for a stationary observer.

Another useful analogy compares this expanding space-time system, the absolute reference system, to an expanding balloon. An expanding three-dimensional object, something on the order of an expanding solid ball, would provide a still closer analogy, but the expanding balloon is a very familiar object, and there should be no difficulty in extrapolating whatever conclusions we reach on this basis from two to three dimensions. Corresponding to the physical objects without independent motion that we have been considering, we may visualize spots painted on the surface of the balloon. The distance between these spots is continually increasing as the balloon expands, but this is not due to any actual motion of the spots; they are fixed to the surface and they *cannot* move. The increase in separation is a property of the *system*, the expanding balloon system in which the spots are located.

If, in addition to the spots, there exist some objects on the surface of the balloon which can move independently, flies perhaps, the true measure of that independent motion will not be the observed increase in separation between these objects and adjacent spots, but the amount by which that observed increase is more or less than that which would have taken place by reason of the expansion alone if the objects had remained fixed to the balloon surface in the manner of the painted spots. Ordinarily we Iook upon the balloon as being located in three-dimensional space, and we view the motion of objects on the balloon surface in the context of a three-dimensional reference system. But it is obvious that any fixed reference system gives us a completely distorted picture of what is going on. It attributes motion to objects such as the painted spots which cannot and do not move, and it gives us a totally unrealistic account of the motion of any objects that do move. For a correct assessment of the situation we must use a moving reference system. Outward motion at the rate of expansion constitutes the datum-the balloon zero, we might call itfrom which we must measure in order to arrive at the true motion of objects on the balloon surface.

The physical situation is similar. We live in a universe which is continually expanding because of the equivalence of the unit of space and the unit of time. Here, too, as on the surface of an expanding balloon, the use of a fixed reference system gives us a completely distorted picture of what is happening. It attributes motion at high velocities to some objects that are no more capable of independent motion than the painted spots on the balloon; it portrays other objects as approximately at rest when they are, in fact, moving at high velocities, and so on. As in the case of the expanding balloon, we can get the true picture only by the use of a moving reference system. We must take the expansion as our datum and measure our quantities from there.

This does not mean that motion with respect to a fixed system of reference is of no consequence to us. On the contrary, such motion is usually our primary concern in the everyday affairs of life. But trying to account for the existence and magnitude of relative motions of this kind on the basis of some hypothetical properties of the physical objects concerned is in the same category as trying to account for the movement of a powerless boat relative to a point on the bank by means of some property of the boat itself. In both cases the situation can be clarified only by recognizing that the physical object involved is located in a moving system-in one case the flowing river, in the other the expanding universe.

The significant point here is that the basic undifferentiated motion outward at unit speed, one unit of space per unit of time, is the *physical equivalent of nothing at all*; it is the datum from which all physical activities extend, the reference system to which all such activities, *or phenomena*, can be related. In order that there may be physical phenomena there must be some deviation from this basic uniformity, some *displacement*, as we will call it, of the one-to-one space-time ratio either in the direction of more space or of more time, and the amount of this displacement determines the magnitude of the phenomenon. The basic physical quantities are not measured from the mathematical zero, but from this unit space-time ratio.

This concept of a “displacement” of the space-time ratio seems to present some difficulty to a number of those who have undertaken to follow the development of theory, but all that is necessary here is to keep in mind that when we use the term “displacement” we are talking about speed. More than one individual has asked at this point, “If you mean speed, why don‘t you say speed?” The reason is that displacement is not merely speed; it is speed measured in an unfamiliar way from an unfamiliar reference point.

As the term is used herein, space or time displacement is measured from unity; it is the deviation from the one-to-one ratio of space to time that constitutes unit speed. Thus it is the deviation from what we may call the physical zero-or perhaps more accurately, the neutral point-rather than from the mathematical zero that constitutes the datum from which speed is ordinarily measured. Furthermore, the study of basic physical phenomena is largely a matter of determin-. ing the effects of successive additions of units of space or time to existing motions, and it will therefore be convenient to work with quantities that are measured in terms of such units. For example, a change from the neutral level that would be reported in terms of speed as a reduction of 1/2 unit followed by a reduction of 1/6 unit, would be reported in terms of displacement as an addition of one time displacement unit followed by another addition of the same kind: a statement that is much more significant from a theoretical standpoint.

The question that naturally arises at this point is, How can these displacements of the space-time ratia exist, when each unit of space is always equivalent to a unit of time? Inasmuch as the progression is scalar, the only variation that can take place is in the scalar direction: outward (positive) or inward (negative) . If both space and time are progressing outward, the unit ratio is maintained. The same is true if they are both progressing inward, or if one is progressing outward and the other inward. But there is one further possibility. One of the components may alternate scalar directions, so that the negative progression of one unit of this component cancels the positive progression of the preceding unit. A series of such reversals thus results in the formation of a multiple unit of motion in which n units of space (or time) are associated with only one unit of time (or space) . The sense of the reciprocal postulate is that in these multiple units of motion the n units of one component are equivalent to 1/n units of the other.

Of course, this does not necessarily demonstrate that such reversals do take place; it merely indicates that they can take place. As indicated at the beginning of this chapter, however, the task of constructing a theory of a universe of motion is essentially a matter of determining what variations of motion can exist and what consequences follow. The theoretical universe is therefore a description of the possible rather than the actual. The final tie-in with reality is provided by showing that what can exist in the theoretical universe coincides with what does exist in the actual physical universe.

While the existence of the displacements is thus explained, the postulates do not provide any means whereby such displacements may be created or destroyed. Consequently, the existing displacements have the character of postulates; they are given features of the universe rather than items developing out of the operation of physical processes. The present total of such displacements must therefore remain constant (unless it can be altered by some agency outside the physical universe. Whether or not such an agency exists is, of course, beyond the scope of this work.) Here is the *conseruation law* in its most general form.

If the change in scalar direction takes place in space, so that n units of time become associated with one unit of space in a velocity ln, the result is a change of location in space. A location which normally would have advanced n units of space during n units of time now advances only one unit. We will describe such a *change of location as motion in space*. There might be some merit in applying the "space" designation to the displacement which is responsible for this motion, especially since it is the space component that deviates from the normal rate of progression. However, the net efEect of a displacement of this character is to increase the number of time units taking part in the particular phenomenon from one to n; that is, n/1 units have, in effect, been added to the time component of the motion while the space component remains at unity. It will therefore be convenient to call this a time displacement, so that when we add time displacement we are adding time, and when we add space displacement we are adding space.

Inasmuch as the limiting value of the quantity 1/n, the spatial speed, is 1/1, it is evident that motion in space cannot take place at a net speed greater than unity. However, this does not mean that there are no net speeds greater than unity; it merely means that such speeds are not spatial speeds. They are temporal speeds, and they result in change of position in time rather than change of position in space. All this follows automatically from the reciprocal relation between space and time.

It also follows from this same relation that whatever is true with respect to the spatial speed is equally true, when the appropriate changes in language have been made, of the inverse (temporal) speed n/1. We can say, then, that a space displacement causes a motion in time, which results in a change in time location. Such a motion cannot have a net speed of less than unity, as the limiting value of the quantity n/1 is 1/1.

These simple motions which are now under consideration are inherently scalar. Whatever spatial or temporal directions may be attributed to them are determined by the reference system that is employed, not by any property of the motions, and assignment of direction by selection of a reference system does not alter their scalar characteristics. Unfortunately, it is not generally realized that such a thing as inhexently scalar motion exists. In fact, the usual physics textbook ignores scalar motion altogether and lists motion (velocity) , together with its primary derivatives-acceleration, etc: as typical examples of vector quantities. The scalar aspects of this vectorial motion are given due consideration. For example, speed is distinguished from velocity. But the existence of motion that has no inherent direction is not mentioned.

However, inherently scalar motion does exist, even in the everyday world. If we examine the motions of the spots on the surface of the balloon that we have been using for purposes of analogy, we will find that they are quite different from ordinary vectorial motions. For instance, if there are three physical objects A, B, and C, in a straight line, and we give the center object B a motion in the direction azuay from A, it moves toward C. But if we consider three spots X, Y, and Z, located in a similar straight line on the surface of an expanding balloon, we will find that while the motion of the center spot Y carries it away from X, just as the motion of B carried it away from A, spot Y does not move toward Z in the same manner as B moves toward C; it actually moves azuay from Z. Furthermore, it moves away from all spots in all directions; that is, it is moving outward in all directions. This means, of course, that it has no direction of its own, The motion is inherently scalar. Whatever direction may be attributed to it in the context of a particular reference system is a property of that system, not of the motian of Y.

Such phenomena as the motion of spots on the surface of an expanding balloon are of little consequence in human life, and the failure of previous investigators to give serious consideration to the scalar motion phenomenon is therefore quite understandable. At the very beginning of our development of the consequences of our fundamental postulates, however, we arrive at the conclusion that the basic motions of the universe are inherently scalar-the normal space-time progression, for instance, is simply outward, without any further qualification-and the status of scalar motion is thereby changed from a matter of little significance to a fundamental factor of majar importance. The subsequent development in this volume can be clearly understood only if it is recognized that both the space-time progression and gravitation (which will be discussed in the next chapter) are inherently scalar.

While a scalar quantity, by definition, has no direction, in the spatial or temporal sense of that term, and has magnitude only, that magnitude may be either positive or negative, as we have already noted. To complete the definition of such a quantity we must specify this scalar direction, as well as the numerical magnitude. In the context of a three-dimensional reference system this quantity, if it is a motion, also acquires a spatial or temporal direction.

This raises another question with respect to terminology. In the first publication in this series, the term “direction” was used in three different applications, including the two just specified. This is technically in order, as the word “direction” has a wide range of meanings in general usage, extending even to nonphysical items, such as the direction of our thinking. But some readers have pointed out that this practice tends to cause a certain amount of confusion, and they have suggested that three different terms be utilized. As it happens, however, the various senses in which the term has been employed are not entirely independent, and for this reason it has seemed advisable to continue the use of “direction” in all three applications, but to add some further identification to distinguish between them. We will therefore speak of vectorial direction, scalar direction (inward or outward) , and space-time direction (toward more space or toward more time) . Where the term “direction” is used without any qualification it is to be understood as meaning vectorial direction, the direction with reference to a three-dimensional coordinate system.

On this basis, any specific unit of the normal space progression has a scalar direction: outward. In the context of a spatial reference system it also has a vectorial direction in three-dimensional space, which we may call AB. If the scalar direction reverses at the end of this unit, in the manner previously discussed, and the next unit of the progression is inward, the vectorial direction also reverses; that is, the direction of the motion with respect to the spatial reference system is now BA. The situation here may be compared to the motion of an automobile, which not only has a vectorial direction such as north or south, but also has a scalar direction, in that it may run either forward (positive) or backward (negative) independently of the vectorial direction in which it is traveling. If the car is on a very narrow road, analogous to the one-dimensional path of the space-time oscillation, and it runs forward in moving north, then if it reverses its scalar direction-that is, runs backward-it moves south.

Reversal of the scalar direction of the motion, as well as the direction relative to a fixed reference system, causes each unit of the alternating progression to cancel the entire effect of the preceding unit, and the net change of location during a two-unit cycle is zero. The directional reversal thus results in an oscillation at a location in three-dimensional space that is stationary in the dimension of the oscillation.

Here we have the first ibhysical abject, the first entity that we encounter in our theoretical development that can be distinguished from the general background. But this is not yet an object with an independent motion. Aside from the oscillation, which causes no net change in location, this object has no capability of motion with respect to either space or time, and it must therefore remain permanently in the same absolute space-time location. As brought out in the preceding discussion, this means that it moves outward relative to a fixed reference system at unit speed. Since the oscillation is the progression in the original dimension, the outward motion takes place in a dimension perpendicular to the oscillation.

The specific nature of the reversals in the oscillating unit is not self-evident, but we can clarify it by noting that a reversal, or any other change in the motion, is equivalent to superimposing a second motion on the original. This second motion necessarily has both a space aspect and a time aspect, hence it involves at least one unit of each. A reversal, or other change, af motion in space (or time) therefore cannot be accomplished in less than one unit of time (or space) . Ivach reversal therefore begins at the midpoint of one unit and is completed at the midpoint of the unit following. The combination of an osciIlating motion in one dimension with an outward progression in a perpendicular dimension thus takes the form of a sine curve in three-dimensional space (or time) .

It is essential to recognize that there is no general reference system to which all spatial quantities can be related. (Nor is there a general reference system for all temporal quantities. In this and similar discussions referring specifically to space, it should be understood that the same considerations also apply to time by reason of the reciprocal relation.) The concept of space as a setting or background in which physical objects exist, as used in the theoretical systems of Newton and Einstein, must be discarded when we accept the idea that we live in a universe of motion, but we can set up a three-dimensional reference system that is essentially equivalent to Newton‘s “absolute space” for translational motion only. If we start at a location in space, as previously defined, and observe the space-time progression from this point, we will find that it can be represented as an expanding sphere with the initial point at the center. The absolute location of the initial point will be somewhere on the surface of a sphere of radius x after x units of time have elapsed. We may then insert three perpendicular axes into this sphere, thus defining a three-dimensional coordinate system to which we can refer locations in space.

A similar reference system can be defined from any other location as a center, but if the sphere centered at location A continues to expand it will ultimately reach the sphere centered at location B, and will thus establish a definite relation between the two, so that locations in both systems can be expressed in terms of either. Any one such system is therefore a universal system of reference. However, it is only a reference system-nothing more-and it is a reference system for translational motion only. The significance of this, in the present connection, is that the space which enters into the oscillation just described cannot be represented in the translational reference system. The oscillating unit is an entity that exists in a location defined by that reference system, but the motion of which it is constituted is totally independent of the translational space.

Later in the discussion we will encounter a striking illustration of this independence of the spatial aspects of different kinds of motion. There are certain combinations of motion that are essentially nothing more than mobile units of space, and we will find that they are able to move through matter, which in turn occupies a location in translational space. To those accustomed to thinking of space as a threedimensional background for physical events, such an idea seems totally absurd, but this is only because the development of thought on the basis of a universe of matter has equated "space" with the space aspect of translational motion. Once it is realized that the conventional "space" is merely the reference system for translational motion, and that the space aspect of other types of motion is independent of the translational reference system, this difficulty disappears.

It may be mentioned in passing that the spatial aspects of the vibrations and rotations that we encounter in our ordinary experience can be related to translational space, as these are motions of the same kind as translational motion of physical objects, differing only in direction. This is not true in the realm af the simple basic motions that we are now considering. The oscillation is not at all similar to the scalar progression from which it is derived. It is motion of an entirely different character, involving some important factors such space or time displacements and reversals of direction that are totally absent in undifferentiated space-time.

Inasmuch as the progression of the oscillating unit is merely outward, without an inherent vectorial direction, the direction with respect to a three-dimensional coordinate system will be determined entirely by chance. Consequently, if a number of such units originate simultaneously at the same spatial location they will be distributed uniformly over all directions. The first observable feature of the theoretical universe is therefore a phenomenon in which oscillating units originate at various spatial locations and move outward from these locations in all directions at a constant unit speed, the path of movement taking the form of a sine curve.

As the various features of the theoretical universe are developed step by step from the basic postulates of the system, we will want to compare these theoretical features with the corresponding features of the observed physical universe, partly as an aid toward a clear understanding of the various points brought out in the development, but more particularly as a demonstration of the fact that the theoretical universe is a true and accurate representation of the actual physical universe. The first issue that we encounter in this connection is the matter of identi fication. The features of the theoretical universe emerge from the development without labels, and before we can demonstrate that some particular one of these features-the oscillating unit that we have just been discussing, far example-is identical with the corresponding feature of the observed universe, we must identify that corresponding feature. The names of the various features are purely arbitrary, and it is therefore impossible to establish a direct correlation with a name, but we can describe the observed feature corresponding to that name, and we can also describe the theoretical feature in terms of the manner in which that feature would manifest itself to observation. If an identification is correct, the two descriptions will coincide. In any event, the identification is selfverifying, as any error will quickly show up as a contradiction or inconsistency.

Ordinarily the identification is practically self-evident. It is obvious, for instance, on the basis of the description that has been given, that the oscillating units we have been discussing are *photons*. The process of emission and movement of these photons is radiation, and the space-time ratio of the oscillation is the *frequency* of the radiation. The one-to-one space-time ratio of the outward progression is the speed of radiation, more familiarly known as the *speed of light*. One of the things we can expect an accurate new theory to do is to clear up the major confusions and uncertainties previously existing in the fields to which it applies, and it is evident that the foregoing explanation accomplishes this result for radiation. The dual aspect of radiation, in which the photon sometimes seems to act as a particle and sometimes as a wave, has been a particularly bafHing problem, but it can now be seen that there is a very simple reason for this duality. The photon acts as a particle (that is, a discrete unit) in emission and absorption because it is a discrete unit. It travels as a wave because the combination of its own inherent oscillating motion with the linear outward motion of the space-time progression takes the form of a wave. The characteristics that could not be reconciled as long as it was thought that we are dealing with the photon alone, and have confronted us with a paradox that, as James B. Conant once said, "seemed intolerable" in the days before we "learned to live with it,"13 can readily be understood as soon as we recognize that what we are actually observing is not the photon alone, but the photon plus the space-time progression.

A still more difficult problem in the radiation field has been the question of a medium. There is ample evidence to show that radiation travels as a system of waves, but no one has been able to conceive of any way in which a wave-like motion can be propagated without a medium or something with the properties of a medium. However, all attempts to detect the existence of a medium have failed, and the theorists have therefore resorted to the same device that primitive man employed whenever he encountered a problem that was beyond his capabilities. They have invented a demon to take care of the matter, a hypothesis that cannot be refuted because it cannot be tested: the hypothesis that space itself has the properties of a medium. The development of the Reciprocal System of theory resolves this issue in an unexpected, but very simple, way. It shows that no medium is necessary because radiation, as such, does not actually move at all. Each photon remains in the same absolute location, the same point in the stream, in which it originates, and it is carried outward by the progression of space-time.

The stream in which the photon-emitting object is located, the datum with respect to which an object without independent motion is stationary, may, and usually does, include a component other than the progression. Thus the frequency of the radiation, as received, and the direction from which it is received, vary with the relative motion of the emitter and the receiver. The speed of travel, however, remains constant at unity.

In approaching the queslion as to why this speed, the speed of light, should remain constant irrespective of the reference system, we are entering an area which has an unusually high emotional content for a scientific issue. The prevailing theory, relativity, won general acceptance only after overcoming strong opposition, based partly on scientific grounds, such as the existence of “paradoxes” which can be explained away only by making use of some expedients of a rather dubious character, but more particularly on the fact that this theory conflicts with some firmly held intuitive concepts. Because of the nature of most of the opposing arguments, the controversy between the supporters and the opponents of relativity, like the analogous controversy over evolution, took on the appearance of a contest between science and non-science. As a result, the present tendency in scientific circles is to close ranks and to assert dogmatically, with Heisenberg, that

It (relativity) has become a permanent property of exact science just as has classical mechanics or the theory of heat.l4

even though those who consider the situation logically and dispassionately are more likely to arrive at a conclusion similar to this from Peter G. Bergmann:

Like all other theories of nature, relativity is certain to require modification, and perhaps even complete replacement, as man‘s actual knowledge of the physical universe increases.l5

In view of the emotional atmosphere that surrounds this subject, it seems advisable to interrupt the develapment of theory long enough to make it clear just what this development is designed to accomplish, and how it is related to existing theories in the fields that it covers. As explained earlier, all of the conclusions reached herein are purely theoretical. It is not contended that they are logical consequences of observed relations in the areas to which they apply, the kind of a foundation on which scientists normally try to erect their theories. The conclusions reached herein are wholly creatures of theory, necessary and unavoidable consequences of the postulated properties of space and time, and they are completely independent of anything that we may happen to know about the actual physical universe. But even though the new theoretical system has not been derived from observational data, comparisons zoith established physical facts have shown an exact correspondence between theory and experience wherever conclusive correlations have been possible, and we are therefore justified in asserting that the purely theoretical universe defined by the consequences of the postulated properties of space and time is a true and accurate representation of the actual physical universe.

What we are undertaking to do with respect to each individual feature of the universe that we discuss is to verify this general statement in application to the particular case; that is, to show that the theoretical conclusions regarding this feature are an accurate representation of that feature, or, where little is known about the phenomenon in question, are consistent with that limited amount of knowledge. We are not undertaking to show that existing theory in the area is wrong, or even ta show that the new theory is better than the one now accepted (if any) . Such issues are irrelevant.

For example, the first physical process that emerged from the theoretical development was the space-time progression. Obviously, this provides an immediate explanation for the recession of the galaxies and the speed of the most distant. In Chapter IV a further development of the theory will explain why the recession speed of the closer galaxies is lower. Here, then, the new theoretical structure gives us a picture of the recession phenomenon that is consistent with everything that we know about the physical situation. It thus qualifies as an accurate representation of the observed recession phenomenon. This is what we have undertaken to produce, and anything further is superfluous. No purpose is served by debating the relative merits of the new theory and its predecessor, a question which, as matters now stand, would have to be decided on the basis of nonscientific preferences and prejudices, inasmuch as both theories are in agreement with the very few facts that are available from observation.

This point that more than one-sometimes many more than onetheory can be in full agreement with experience in a limited physical area is something that is too often ignored in present-day practice. As Professor Herbert Dingle puts it, "A theoretical demonstration that the theory contains no internal contradictions-that it could be right - has frequently been regarded as a proof that it is right."16 This logical fallacy is especially in evidence in the attitude toward theories such as relativity to which there is a strong emotional attachment. It is a well-known fact that there are other explanations that are equally as consistent with the observations as relativity. "There are some other logical questions raised by the theory of relativity," says Hesse, "because there are a number of alternative theories which all appear observationally equivalent."17 The truth is that relativity is merely a largely arbitrary selection from among these theories.

Thus, the requirement that a theory must be consistent with the data from observation, which the new system must be prepared to meet in order to justify the claim that it is an accurate representation of the physical facts, does not include a requirement that it be consistent with relativity theory. Agreement with one of the other theories that are "observationally equivalent" would be equally satisfactory, or alternatively, a tatally new explanation that meets the observational tests could be produced. The latter is what has actually happened. Development of the postulated properties of space and time leads to a theory of the composition of velocities that is fully in accord with experience, but is altogether different from anything that has appeared heretofore.

The essential feature of this new theory is the broader view of the nature of time that is implicit in the concept of a universe of motion. The conventional view of time is that it is the entity that is measured by a clock, but the new theory based on the "motion" concept says that the clock measures only the time progression, and not total time. This is equivalent to the kind of a space measurement that we would make in a distant galaxy if we measured only the movement of an object due to the recession and did not recognize any motion of the object in the three-dimensional space occupied by the galaxy. For present purposes this is all we need, or can use, just as clock time was adequate for our purposes when we were not dealing with any very high velocities. But if we improve our instruments to the point where we can detect fast-moving objects within the distant galaxy, we will find that the recession alone does not give us the correct measure of the change in position of such an object. To get the right answer we will also have to take into account the movement in threedimensional space, the coordinate space, as we will call it.

By reason of the reciprocal relation between space and time, the same situation exists with respect to time measurements. In the ordinary affairs of our daily life the only time that we need to take into consideration is clock time, because changes of position in what we may call coordinate time, the time analog of coordinate space, are negligible. But at high velocities the motion in coordinate time becomes an important factor. At the velocity of light, motion is taking place in time at the same rate as in space: a one-to-one ratio. In Fig. l, two photons are emitted simultaneously from point O in opposite directions. At the end of one unit of clock time they have reached A and B respectively. According to Newton, the relative velocity is the separation that has taken place in space, two units,

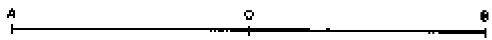

FIG. 1

divided by the elapsed clock time, one unit, the result being two units of velocity. But the experimental evidence indicates that if this relative velocity could be measured it would be found to be one unit, not two units; that is, the velocity of light is always unity, irrespective of the reference system.

The experimental discovery of the constant velocity of light invalidated Newton's relations in application to high velocities, and made it necessary to develop a new theory. To Einstein, working within the context of a universe of matter, and committed to the proposition that time is something that is measured by a clock, there appeared to be only one answer: abandoning the idea of absolute magnitudes and substituting the concept of magnitudes that are inherently variable. His solution for the problem of Fig. 1 was to postulate the constant velocity of light, and to assert that the space and time magnitudes are automatically modified to the extent necessary to produce this result.

Einstein realized . . . that the only possible way in which a person moving and a person standing still could measure the speed (of light) to be the same was that their sense of time and their sense of space are not the same, that the clocks inside the space ship are ticking at a different speed from those on the ground, and so forth. (Richard Feynman) 18

The findings of this work now show that Einstein‘s hypothesis is not “the only possible way” to take care of the problem. It may have been the only possible way that the problem could be solved within the confines of the artificial restrictions that Einstein placed on the situation-that is, within the context of a universe of matter and without modifying the accepted concepts of the nature of space and time-but this point is irrelevant. In the context of a universe of motion, there is another way. The development based on the “motion” concept has revealed the existence of an aspect of the universe hitherto unknown-coordinate time-and all that is necessary in order to solve the problem of the composition of velocities is to take the coordinate time into accaunt in the proper manner.

In Fig. l, what is required is to realize that from the standpoint of photon A, only the space OA and the corresponding time oa are components of the space-time progression that is responsible for the motion of A. The clocks therefore register only the time oa. The space OB does not enter into the progression of A; it is another unit of space, a unit of coordinate space, as has always been recognized. The point of the new explanation is that the same is true of the corresponding time ob. This is another unit of time, and with respect to photon A it is a unit of coordinate time, a unit that is not involved in the progression of A.

In the context of a stationary temporal reference system, both oa and ob are intervals in coordinate time. But oa is the time interval through which the progression carries photon A while it is moving from O to A in space, and this is the interval that is registered by clock A. The time interval ob through which photon B moves coincidentally has no relation to the progression of photon A, and it is not registered on clock A. Gonversely, clock B registers the time interval ob, which is the time involved in the progression of photon B, but not the time interval oa. Thus both clocks register the same arnount of time, as they must, since the speed of the progression is always unity, but neither registers the full time interval by which the two phatons are separated when they reach spatial locations A and B respectively. At this juncture, where they are separated by two units of space they are likewise separated by two units of time, and the equation of motion is 2/2 = 1, which agrees with the observations. At lower velocities, the coordinate time increment, the time interval that is not involved in the progressian and hence does not register on a clock, is smaller, and at the ordinary velocities of everyday li£e it is negligible. There are some observed physical phenomena, how ever, in, which the effect is appreciable, and in application to these phenomena the coordinate addition to the clock time produces the same mathematical results as the theory of relativity. These mathematical results are frequently portrayed in current literature as “proofs” of the validity of the relativity theory, but this is the kind of non sequitur mentioned by Dingle: accepting a showing that the theory could be right as proof that it is right.

Such loose reasoning is always unsound practice, but it is even more illogical than usual in the case of the claims made for special relativity, as the mathematical relations from which the results have been obtained, the Lorentz equations, were not even derived from the relativity theory. They antedated the theory and are independent of it. Einstein‘s contribution was to furnish a plausible explanation of these empirically discovered relations, one that had no more scientific foundation than the explanations previously available, but was philosophically more acceptable to most scientists. The observed conformity of various phenomena with the mathematical relations does not confirm the validity of Einstein‘s explanation. It merely means that any one of the many mathematically equivalent theoriesrelativity, the several “observationally equivalent” theories mentioned by Hesse, or the theory described herein, based on the concept of motion in time-could be correct. The difference between these theories is merely in their respective explanations of the origin of the observed effects.

Here again, then, the new system does its job; it produces a true and accurate representation of the physical facts. Any question as to which is the “better” theory is meaningless in this connection. The new theory does all that can be expected of it; all that any theory can do. It is worth mentioning, however, that the discovery of the existence of a second time component that modifies the clock time under certain circumstances reveals why it has not been possible to extend the special theory to the general situation of non-uniform motion. A system of n components can be represented by n/1 variables only where some regularity permits expressing the extra component in terms of one of the others. For example, if we knew nothing of the property of direction, but could measure speed and also the progress toward a certain designated point, and we were trying to express one of these quantities in terms of the other, we would be successful in certain cases where there is a definite relation between the two, as in uniform linear motion, but we could not formulate any general relation, simply because there is no such relation. Before we could set up anything applicable to the general situation we would have to discover the property of direction, and start measuring vectorial quantities. Discovery of the additional time component is, in a sense, comparable to the discovery of the property of direction.

No doubt many will find it difficult to believe that any significant basic feature of the universe could still remain undetected after physical science has attained as high a stage of advancement as that which currently prevails. But it should be remembered that all of the results thus far obtained by physical science have been based on the concept of a universe of matter, which is now definitely known to be erroneous, and what has been accomplished to date therefore represents the best that science has been able to achieve in working from the wrong premises. This past experience does not in any way delimit the potentialities of a correct theory. Coordinate time is only one of a number of hitherto unknown physical features of prime importance that have been brought to light by the development of the details of a universe of motion. The previous inability to detect these phenomena is simply part of the price that science has paid for building its structure of theory on an erroneous basic concept.

CHAPTER IV

Rotational Motion (Matter)

Thus far we have been dealing with linear motion only. Rotational motion is also permitted by the geometry of three-dimensional space (or time) , but before rotation can take place there must be something that can rotate, and rotational motion therefore cannot be generated directly from the motion of the space-time progression. The existence of a one-dimensional oscillating unit, the photon, now provides the necessary “something.” Our next task will be to examine the theoretical aspects of the rotation of the photon. We will first consider the characteristics of rotational motion per se, and then the special features that result from the fact that it is a photon that is rotating rather than something else.

A significant feature of rotation is that it accomplishes a reversal of the vectorial direction of the motion without a reversal of the scalar direction. As previously pointed out, the oscillating progression of the photon first moves forward one unit and then backward over the same unit, reversing the scalar direction when it reverses the vectorial direction.

But an object that is rotating forward continues moving forward regardless of the changes in vectorial direction that are occurring. The difference between these two situations can be emphasized by returning to the automobile analogy. If this car periodically reverses direction, so that it moves back and forth over the same path, as in the case previously considered, a speedometer that runs in reverse during backward motion will register zero after any number af complete cycles, whereas if the car moves around in a circle it will accomplish the same result from a directional standpoint -that is, each complete cycle will put it back where it started-but the speedometer will continue registering forward mileage.

For a closer analogy, let us now assume that this automobile is operating on the surface of a very large balloon, and let us further assume that the speedometer is connected with the inflation mechanism of the balloon in such a manner that a positive speedometer registration causes the balloon to expand, whereas a negative regis tration causes it to contract. Finally, let us assume that the path of travel, linear in one case and circular in the other, is clearly identified by appropriate markings. Regardless of whether the car moves back and forth on the linear path or moves around the circle, it stays on the painted strip; that is, it remains in the same location on the surface of the balloon. But the back and forth motion makes no change in the size of the balloon and consequently the separation between the original car and any other similar car on the surface of the balloon remains constant, whereas the motion in a circle causes either an expansion or a contraction of the balloon, depending on whether the motion is forward or backward. In this case the separation between any two such cars increases or decreases, even though each remains in a fixed location on the balloon surface.

In the physical situation the mechanism is less complicated, but otherwise quite similar. The oscillating motion of the photon, like the back and forth motion of the motor car, has a scalar resultant of zero, but the rotational motion of the photon maintains the same scalar direction continuously, and it therefore alters the separation between this and every other rotating photon, just as the circular motion of the cars on the balloon surface, under the assumed conditions, changes the distance between them.

One important difference between the two situations is that rotation of the photon can take place only in the negative, or inward scalar direction. For an explanation of this fact we need to consider the limits to which rotational motion is subject. Rotation at unit speed in the outward scalar direction is meaningless, since unit outward speed is the physical zero, the physical equivalent of nothing at all, and no rotation cannot be distinguished from no translation. Motion of any kind in space at a speed in excess of unity is impossible, as we have already noted, and since there are no fractional units, outward rotation of the photon is totally excluded. But rotation at unit speed in the inward scalar direction does have a physical significance; it nullifies the outward motion of the progression and reduces the net speed to zero. Furthermore, it is possible to have one additional unit of inward motion, two full units altogether, without exceeding the limiting value of one net unit. The photon therefore rotates in the inward scalar direction.

A rotating photon thus reverses the normal outward progression and moves inward in space toward all space-time locations as if it were located on a contracting balloon. This inward motion of each individual unit cannot be detected in any direct manner, but since all such rotating photons are moving inward, the visible effect of the motion is that each is moving toward all others, as if they were exerting mutual forces of attraction.

We are now ready to make some more identifications. By the same procedure as before, we identify the rotating photons, with certain exceptions that we will discuss later, as atoms. Collectively, the atoms constitute matter, and the inward motion due to the inherently scalar nature of the rotation is *gravitation*.

As in the case of radiation, the development of this new and accurate theory resolves the seemingly insuperable diffculties that have hitherto stood in the way of a clear understanding of the gravitational phenomenon. The origin of gravitation is now evident. The same thing that accounts for the existence of the atom, the rotation in the inward scalar direction, also causes it to gravitate. Furthermore, the nature of this gravitational motion explains those peculiar characteristics of the phenomenon that have been so bafHing to previous investigators. As nearly as can be determined from observation, gravitation acts instantaneously, without an intervening medium, and in such a manner that its effects cannot be screened off or modified in any way, but all attempts to account for these characteristics in terms of previous physical theories have been so fruitless, and seemingly so hopeless, that the task has long since been abandoned. For many decades, all theoretical developments in this area have been based on the premise that, for some unknown reason, the physical observations are giving us false information; that notwithstanding all of the observational evidence to the contrary, gravitation must be propagated at a finite velocity, through a medium or something with the properties of a medium, and that screening or “anti-gravity” measures would probably be feasible if the right methods could be discovered.

The findings of the Reciprocal System now show that the observations are not misleading; they give us a true picture of the situation. The instantaneous action, the absence of a medium, and the impossibility of screening are all explained by the fact that gravitation is not an action of one mass upon another, as it appears to be. In reality each atom of matter is following its own course independently of all others, and the apparent interaction is an illusion created by the fact that all atoms are moving inward in space simultaneously, and hence each is moving toward all others. There is no propagation of an effect of one upon another, and no need for a medium to transmit such an effect.

Both the outward motion of the photon and the inward motion of the atom are scalar motions of the same general character. There is a difference, however, in the way in which these two motions manifest themselves in three-dimensional space. In both cases the direction of the motion with reference to a three-dimensional coordinate system is determined by chance, since a scalar motion has no inherent vectorial direction. The direction of movement of the photon is determined at the moment of emission, and inasmuch as this photon remains permanently in the same absolute location there is no change in direction unless the photon encounters an obstacle of some kind. The atom, on the other hand, is moving in opposition to the spacetime progression, and is therefore continually passing from one spacetime unit to another. Each such change of absolute location involves a redetermination of the spatial direction of the scalar motion, another chance event, and in the long run the motion of each atom is distributed over all spatial directions; that is, the atom is moving inward in space in all directions. From geometrical considerations we deduce that at distance d from the atom the motion is distributed over a spherical surface of radius d, and the portion of the total motion that is directed toward a unit area at this distance depends on the ratio of that unit area to the total area of the spherical surface, which means that it is inversely proportional to d2. This is the familiar inverse square relation: the (apparent) gravitational effect is inversely proportional to the square of the intervening distance.

Gravitation is generally visualized in terms of force rather than in terms of motion, and it will be desirable to establish the relation between these two concepts. For this purpose, let us consider a situation in which an object is moving in one direction with a certain velocity, and is simultaneously moving in the opposite direction with an equal velocity. The net change of position of the object is zero, and instead of looking at the situation in terms of two opposing motions, we may find it convenient to say that the object is motionless, and that this condition has resulted from a conflict of two forces tending to cause motion in opposite directions. On this basis we define force as that which will cause motion if not prevented from so doing by other forces, and we define the magnitude of the force as the product of mass and acceleration.

This kind of a conceptual device, which replaces the true relationship with an equivalent that can be more easily manipulated, is a perfectly legitimate scientific tool, but its use is subject to certain hazards because the boundary conditions of the substitute are not usually the same as those of the original concept. In the present in stance, there is a definite limit to the velocity that can be atfained in space, but the concept of force contains no hint of any such limitation, and its existence has not been recognized. This, in turn, has led to some misconceptions concerning the behavior of related quantities.

The basic error in this case is the assumption that a force applied to the acceleration of a mass remains constant irrespective of the velocity of the mass. If we look at this assumption only from the standpoint of the force concept it appears entirely logical. But when we look at the situation in its true light as a combination of motions, rather than through the medium of an artificial representation by means of the force concept, it is immediately apparent that there is no such thing as a constant force. The space-time progression, for instance, tends to cause objects to acquire unit velocity, and hence we say that it exerts unit force. But it is obvious that a tendency to impart unit velocity to an object which is already at a high velocity is not equivalent to a tendency to impart unit velocity to a body at rest. In the limiting condition, when the mass already has unit velocity, the force of the space-time progression (the tendency to cause unit velocity) has no effect at all, and its magnitude is zero.

By way of analogy, we may consider the case of a container partially filled with water. If the container is rotated, the speed of rotation is gradually communicated to the water. At low water velocities, the effective force, and consequently the acceleration, are approximately constant. But even though there is no change in the source from which this “constant” force originates, the acceleration decreases and approaches a zero limit as the water speed approaches the speed of the container. Similarly, the source of the "constant" force of present-day physical experiments-an electric potential, for instance -may remain unchanged, but the efect of the force decreases as the limiting unit velocity is approached.

It is evident, on this basis, that the full effect of any force is at. tained only when it is exerted on a body at rest, and that the effective force component in application to an object in motion is a function of the difference in velocities. Ordinary terrestrial velocities are so low that the corresponding reduction in effective force is negligible, and at these velocities a force such as that due to an electric potential can be considered constant. Experiments indicate, however, that acceleration decreases rapidly at very high velocities and approaches zero as the velocity of the mass to which the force is applied approaches unity. Relativity theory explains the experimental results by the assumption that the mass increases with velocity and becomes infinite at unit velocity (the velocity of light) . In the theoretical universe being developed from the postulates of the Reciprocal System this explanation is not acceptable, as mass is constant, but the same results are produced by the decrease in the effective force as the velocity increases. In mathematical terms, the limiting zero value of a in the expression a = F/mm (which is the fact determined by experiment) is not due to an infinite value of m but to a zero value of F.

The conclusion to be drawn here is not that the use of the concept of force should be abandoned, but that due care should be used in its application, so that the benefits of this convenient device can be realized without falling into serious errors. Much the same can be said of the use of the concept of "gravitational force." As has been brought out, there actually is no such thing; the truth is that one mass has no effect whatever on another. But within certain limitations masses behave as i f they were exerting mutual forces of attraction, and dealing with them on this basis is a convenient practical expedient. In the subsequent discussion, therefore, we will follow common practice and refer to gravitation as a force exerted by masses upon other masses, except where recognition of its true status as motion is necessary in order to avoid erroneous implications.

It is essential to keep in mind, however, that the gravitational force with which we will be dealing is not a real force. It is only an "as if" force, and it does not have all of the properties of a real force. In particular, it involves no transmission or propagation. The "gravitational waves" that are now being sought so assiduously are wholly non-existent. Gravitational effects, changes in the "as if" gravitational forces, can be detected, of course. For example, the gravitational effect of the moon, as experienced at any specific terrestrial location, is continually changing, and if the results now being reported from gravitational detectors of one kind or another are actually of gravitational origin, they are minor variations of a similar, but less regular, nature. They are not waves of the kind that are required by current theory: phenomena analogous to light waves that are capable of transmitting gravitatianal forces. All of the effects of gravitation appear instantaneously, and there is no interaction time. No screening is possible because there is nothing to screen. The so-called "antigravity" devices must remain a feature of science fiction. In real life the only anti-gravity device is oppositely directed motion.

The next aspect of gravitation that we will want to consider is the effect of mass concentration. According to the theory explained in the preceding pages, each gravitating mass is moving uniformly inward in space toward all space-time locations. Every mass unit occupies both a location in space and a location in time. A rough analogy would be the location of an object on the surface af the earth. Such an object has a location in latitude, measured from the nearest pole, and a location in longitude, measured from the

Greenwich meridian. For a complete definition of the position of the object, both of these locations must be specified. The mere fact that a number of objects are all at the same latitude does not mean that they are coincident. If their locations in longitude are random, each of the objects occupies a different position.

The gravitational process in the material universe causes aggregation of matter in space only, while the coexisting progression of time continues unchecked. As a result, the atoms of a material aggregate are contiguous in space but widely dispersed in time. An aggregate of n mass units therefore occupies n space-time locations, even though the entire aggregate may occupy approximately the same space location. Gravitation moves every other mass within the efEective limits toward each of these space-time locations independently, and the total motion toward the n-unit mass is therefore n times the motion toward a single unit of mass occupying a single space-time location. The same considerations apply to the reference mass, and the total motion of an n-unit mass toward a specific space-time location is n times that of a single unit of mass.

An issue that is frequently raised by those who encounter this gravitational theory for the first time concerns the response of the gravitational force of mass A to a change of position of some distant mass B. The question that is usually asked runs something like this: "If, as the theory claims, this is not actually an effect transmitted from A to B, but is an independent motion of mass A, how does mass A know what has happened to B, so that the gravitational motion of A can take place in the right amount and in the right direction?"

The answer is that the gravitational motion of mass A never changes, either in amount or in direction. It is always directed from the location of the gravitating unit toward all other space-time locations. But we cannot observe the motion of an object inward in space; we can only observe motion relative to other objects whose presence we can detect. The motion of each object therefore appears to be directed toward the other objects, although, in fact, it is directed toward all locations in space-time irrespective of whether or not they happen to be occupied. Whatever changes take place in the gravitational phenomena by reason of change of relative position of the gravitating masses are not changes in the gravitational motions (or forces) but changes in our ability ta detect those motions.

Let us assume an object X occupying location a. This object is moving gravitationally toward all other space-time locations. Inasmuch as we cannot observe time locations, we will consider only the space Iocations, two of which we will designate b and c. If these locations are not occupied, then we cannot detect the gravitational motion at all. But if location b is occupied by object Y, then we see X moving toward Y; that is, we can now observe the motion of X toward location b, but the motion of X toward location c is still unobsQrvable. The observable gravitational motion (or force) of Y is toward X and has the direction ba.

Now, if Y moves to location c, what happens2 The essence of the theory is that the motion of X is not changed at all; it is entirely independent of the position of object Y. But we are now able to observe the motion of X toward c because there is a physical object at that location, while we are no longer able to detect the motion of X toward location b, even though that motion exists just as definitely as before. The direction of the gravitational motion (or force) of X thus appears to have changed, but what has actually happened is that some previously unobservable motion has become observable, whereas some previously observable motion has become unobservable. The same is true of the motion of object Y. It naw appears to be moving in the direction ca rather than in the direction ba, but here again there has actually been no change. Gravitationally, Y is moving in all directions at all times.

Having examined those aspects of gravitation that are relevant to the discussion in the subsequent pages, we are now ready to begin consideration of the details of the atomic rotation of which gravitation is one aspect. It is evident at the outset that the photon, a onedimensional oscillation, cannot rotate around itself as an axis. Such a rotation would be indistinguishable from no rotation at all. But it can rotate around either or both of the axes perpendicular to the path of oscillation at its midpoint. One such rotation generates a two-dimensional figure, a disk. Rotation of the disk in another dimension then generates a three-dimensional figure, a sphere. Since this exhausts the available dimensions, further rotation in the same scalar direction is impossible, and the basic rotation af the atom is therefore two-dimensional.

But even though no further rotation of the same kind is possible, a rotation can take place in the opposite scalar direction around the third axis. Since the basic two-dimensional rotation is distributed through all three dimensions of space, the reverse rotation is not required for geometric stability, and it is therefore only a possibility, not a necessity. The rotational motion of the atom thus consists of a two-dimensional rotation, with or without a one-dimensional rotation in the opposite scalar direction.

Another important point is that two separate two-dimensional rotations may be combined in one physical unit. The nature of this combination can be illustrated by two cardboard disks interpenetrated along a common diameter C. The diameter A perpendicular to C in disk A represents one linear oscillation, and the disk A is the figure generated by a one-dimensional rotation of this oscillation around an axis B perpendicular to both A and C. Rotation of a second linear oscillation, represented by the diameter B, around axis A generates the disk B. It is then clear that disk A may be given a second rotation around axis A, and disk B may be given a second rotation around axis B without interference at any point, as long as the rotational velocities are equal.

Here, again, the second rotating system is not necessary for stability. Units in which there is only one two-dimensional rotation can and do exist. But as a general principle low numbers are more probable than higher numbers and symmetrical combinations are more probable than asymmetrical combinations. Hence, if a second twodimensional displacement is added to a one-unit rotation, probability considerations require the added displacement to generate a second rotating system rather than adding to the existing rotation. The combinations with only one two-dimensional rotation are therefore limited to those which do not possess more than one unit of rotational displacement.

For convenience in the subsequent discussion it will be desirable to introduce some new terminology to identify the various features of the atomic rotation. We will call the one-dimensional rotation electric rotation, and the corresponding axis the electric axis. Similarly we will refer to the two-dimensional rotation as magnetic rotation around the magnetic axes. If the displacements in the two magnetic dimensions are unequal the rotation is distributed in the form of a spheroid, and in this case the rotation that is effective in two dimensions of the spheroid will be called the ~rincipal magnetic rotation and the other will be the subordinate magnetic rotation. Designation of these rotations as electric and magnetic does not indicate the presence of any electric or magnetic forces in the structures now being described. This terminology has been adopted because it not only serves our present purposes, but also sets the stage for the introduction of electric and magnetic phenomena in a later phase of the development.

Each of these rotations may assume any one of a number of possible displacement values. This means that many difEerent combinations can exist, and since the physical behavior of the atoms depends on the magnitude of these rotational displacements, the various rotational combinations can be distinguished by differences in their physical behavior, by differences in their properties, we may say.

We will now identify these rotational combinations as the chemical elements, each rotating unit of a particular kind constituting an atom of that element. For convenience in referring to the various combinations of rotational displacement a notation in the form 2-2-3 will be used in the discussion, the three figures representing the displacements in the principal magnetic, the subordinate magnetic, and the electric ratational dimensions respectively.

It should be noted at this point that the value taken as the unit of magnetic displacement is somewhat arbitrary, as the magnitude of an increment of this two dimensional displacement, in terms of the basic unit, the electric unit, is variable. At the single unit level dimensional distinctions disappear; that is, 12 is equal to 1, and the magnetic unit is therefore equivalent to the electric unit. However, in those rotational combinations with two magnetic rotations, the combinations that we recognize as atoms of matter, both rotations must have the same speed, in order to avoid interference, and the equivalent of two of the single units is therefore required to give the structure as a whole one unit of magnetic rotation. It will be convenient to define this double unit as the magnetic rotational unit in the material atoms, retaining the single unit, the natural unit, in the subatomic combinations. The electric (one-dimensional) equivalent of n magnetic (two-dimensional) units, as thus defined for the atoms of matter, is 2n2.

In applying this 2n2 relation between the magnetic and electric units it is necessary to take into account some mathematical characteristics of the space-time progression. In the undisplaced condition all progression is by units. We have first one unit, then another similar unit, yet another, and so on, the total up to any specific point being n units. There is no term with the value n; this value appears only as the total. The progression of displacements follows a different mathematical pattern because in this case only one of the space-time components progresses, the other remaining fixed at the unit value. The progression of 1/n, for instance, is 1/l, 1/2, 1/3, and so on. The progression of the reciprocals of 1/n is 1,2,3 . . . n. Here the quantity n is the final term, not the total. Similarly, when we find that the electric equivalent of a magnetic displacement n is 2n2 , this does not refer to the total from zero to n; it is the equivalent of the nth term alone.

Inasmuch as motion is a relation of space to time, motion of an existing physical unit-that is, addition of mation of a difEerent type-requires a displacement with the opposite space-time direction. Where the displacements have the same direction, an addition merely modifies the quantity of the existing type of motion. The rotating units that constitute atoms may therefore be linear space displacements rotating with net time displacement, or linear time displacements rotating with net space displacement. The latter combinations, however, do not constitute matter, and for the present, the discussion will be confined to those combinations with net rotational time displacement. Unless otherwise specified the displacement values that are given will refer to time displacement. If space displacement is present it will be identified by enclosing the applicable figure in parentheses.

Looking first at those combinations which have zero electric displacement, a single unit of magnetic time displacement results in the combination 1-0-0. This single displacement unit merely neutralizes the oscillating unit of space displacement, and the result is the rotational base, a unit with a net displacement of zero; that is, the rotational equivalent of nothing. One additional unit of magnetic time displacement produces the combination 1-1-0. This combination still does not have the properties that we recognize as those of matter, as it has only one effective magnetic displacement unit and hence only one magnetic system of rotation. The first combination that qualifies as matter requires one more unit of magnetic displacement, bringing the system up to 2-1-0, which can be identified as the element helium. Additional units of magnetic displacement produce a series of elements that we can recognize as the inert gases. The complete series is as follows:

Displacement	Element	Atomic No.
2-1-0	Helium	2
2-2-0	Neon	10
3-2-0	Argon	18
3-3-0	Krypton	36
4-3-0	Xenon	54
4-4-0	Radon	86
5-4-0	Unstable	118

The number of possible cambinations of rotations is greatly increased when electric displacement is added to these magnetic combinations, but the combinations that can actually exist as elements are limited by the probability relations. The magnetic displacement n is numerically less than the equivalent electric displacement 2n2, and is correspondingly more probable. Any increment of displacement consequently adds to the magnetic rotation if possible rather than to the electric rotation. This means that the role af the electric displacement is confined ta filling in the intervals between successive additions of magnetic displacement.

On this basis it can be seen that if the atomic rotation involved nothing but time displacement, the series of elements would start at the lowest possible magnetic combination, helium, and the electric time displacement would increase step by step until it reached a total of 2n2 units, at which point the relative probabilities would result in conversion af these 2n2 units into one additional unit of magnetic time displacement, whereupon the building up of the electric displacement would be resumed. This behavior is modified, however, by the fact that electric displacement in matter, unlike magnetic displacement, may take either space-time direction.

As previously mentioned, a net rotational time displacement is required in arder to produce those properties that are characteristic of matter. It necessarily follows that the magnetic displacement, which is the majar component of the total, must also be a time displacement. But as long as the larger component has the time direction, the system as a whole can meet the requirement of a net time displacement even if the smaller component, the electric displacement, is a space displacement. It is possible, therefore, to increase the net time displacement a given amount either by direct addition of the required number of units of electric time displacement, or by adding magnetic time displacement and then adjusting to the desired intermediate level by adding the appropriate number of units of the oppositely directed electric space displacement.

Which of these alternatives will actually prevail is again a matter of probability, and from probability considerations we deduce that the net displacement will be increased by successive additions of electric time displacement until n2 units have been added. At this point the prababilities are nearly equal, and as the net displacement increases still further, the alternate arrangement becomes more probable. In the second half of each group, therefore, the normal pattern involves adding one unit of magnetic time displacement and then reducing to the required net total by adding electric space displacement, eliminating successive units of the latter to move up the atomic series.

By reason of this availability of electric space displacement as a component of the atomic rotation, an element with a net displacement less than that of helium becomes possible. This element, 2-1-(1), which we identify as hydrogen, is produced by adding one unit of electric space displacement to helium and thereby, in effect, subtracting one displacement unit from the equivalent of four units (above the 1-0-0 datum) that helium possesses. Hydrogen is the first in the ascending series of elements, and we may therefore give it the atomic number 1. The atomic number of any other element is equal to its equivalent electric time displacement less two units.

One electric time displacement unit added to hydrogen eliminates the electric space displacement and brings the combination back to helium, atomic number 2, with displacement 2-1-0. This displacement is one unit above the initial level of 1-0-0 in each magnetic dimension, and any further increase in the magnetic displacement requires the addition of a second unit in one of the dimensions. With n=2 the electric equivalent of a magnetic unit is 8, and the next group therefore contains eight elements. In accordance with the probability principles, the first four elements of the group are built on a helium type magnetic rotation with successive additions of electric time displacement. The fourth element, carbon, can also exist with a neon type magnetic rotation and four units of electric space displacement. Beyond carbon the higher magnetic displacement is normal, and the successive steps involve reduction of the electric space displacement, the final result being neon, 2-2-0, when all space displacement has been eliminated. The following elements are included in this group:

Displacement	Element	Atomic No.

2-1-1	Lithium	3
2-1-2	Beryllium	4
2-1-3	Boron	5
2-1-4	Carbon	6
2-2-(4)		
2-2-(3)	Nitrogen	7
2-2-(2)	Oxygen	8
2-2-(1)	Fluorine	9
2-2-0	Neon	10

Another similar group with one additional unit of magnetic displacement follows. When this group is complete at element 18, argon, 3-2-0, the magnetic displacement has reached a level of two units above the rotational datum in both magnetic dimensions. In order to increase the rotation in either dimension by an additional unit, 2 X 32 or 18 units of electric displacement are required. This results in a group of 18 elements, which is followed by a similar group differing only in that the magnetic displacement is one unit greater.

The effective magnetic displacement now steps up to 4 in one dimension, and consequently there are 32 members in each of the final two groups. Only about half of the elements in the second of these groups have actualIy been identified thus far, but theoretical considerations indicate that the group could be completed under favorable conditions. At 5-4-0 the displacement is 4 units above the 1-0-0 datum in both magnetic dimensions. As indicated in previous publications where the atomic rotation was covered in more detail, this represents the Iimit at which the rotational character of the motion is lost and the displacement reverts to the linear basis. The next preceding element, 5-4- (1) , atomic number 117, is therefore the heaviest element that can be stable under the most favorable conditions.

The three rotational displacement values that are characteristic of each element are the factors, individually, in total, and in the various modifications to which they are subject in association with other elements, that determine the magnitudes of the properties of the elements. For example, when the appropriate values are inserted in an equation given in the first book of the present series, the result is the corresponding inter-atomic distance. Similar mathematical relations, some already published and others still awaiting publication, enable computation of many other physical properties. The ability o£ these theoretical expressions to reproduce the observed values in so many different areas is conclusive evidence of the validity of the theoretical system from which they were derived, but the subject matter to which they apply has no direct bearing on the objective of this present volume, and since the evidence contributed by these mathematical expressions is not actually needed for pr~ent purposes it will not be considered here.

Even without this great mass of additional confirmation, the items already discussed are more than ample to show that, in the description of the nature and basic features of the atoms of matter, as in the areas previously covered, the new theoretical system is an accurate representation of the physical facts. Once again, a development of the consequences of the postulated properties of space and time has led us to a totally new explanation of an important feature of the physical universe, and again we find a full agreement with observation. In a universe of motion, atoms of matter are, of course, combinations of motion, and our analysis shows that the number of dif. ferent types of atoms (elements) that are known to exist, and the arrangement of these elements into groups defined by their properties, are exact duplicates of the number and arrangement of the rotational combinations that can theoretically exist above a certain minimum.

In this universe of motion, the rotational combinations that can exist, but are below the minimum required for qualification as atoms of matter, are sub-atomic particles. On this basis, sub-atomic particles are not constituents of atoms, as present-day theory sees them, they are incomlblete atoms. The status of all physical entities as nothing more than combinations of motion is the explanation for the observed interconvertibility of these entities: a finding that has delivered the coup de grace to the concept of a universe of matter. If matter is basic, it cannot be converted to motion or to anything else. But it can be converted to motion; hence it is not basic. This is the simple indisputable fact that demolishes the "matter" concept.

In a universe of motion, where matter is motion, and sub-atomic particles are motion, and radiation is motion, and linear change of position is motion, where what is and what it does are both motion , anything physical can be converted into anything else physical, by appropriate processes, because all this amounts to is altering the form of the motion.

Perhaps, at last, man is probing. to that level of understanding where there is no clear distinction between what is and what happens, where the components of the world and the interaction of those components, one with another, are indistinguishable ideas. (K. W. Ford) 19

Yes, Dr. Ford, that is how it is,

CHAPTER V

Destructive Limits

Although the preceding chapters have been devoted to an examination of the fundamentals of physical existence rather than being directed specifically at the astronomical phenomena that are the subjects of our present inquiry, they have nevertheless outlined the general framework of the astronomical world. They have shown that the concept of a universe of motion Ieads directly to an explanation of the existence and general properties of the matter of which stars and galaxies are composed, the gravitation that controls their destinies, and the radiation by means of which our information concerning these objects is obtained. Here, then, we have the foundation for a general astronomical theory.

In dealing with such phenomena as quasars and pulsars, however, we will be concerned not so much with the nature, origin, and behavior of the various constituents of the astronomical universe as with the processes by which these constituents are ultimately destroyed, and the products resulting from their destruction. These processes, we will find, involve destruction of matter itself, and it will therefore be necessary to extend our consideration of the structure of matter to a determination of the limits to which this structure is subject and the nature of the influences that result in the attainment of these limits. For this purpose we will take a brief look at some additional types of motion.

Before beginning this discussion it will be advisable to make a few comments with respect to the mathematical aspects of the Reciprocal System of theory. One of the most significant features of this system is that numerical values appear at the very start of the theoretical development-the numerical pattern of the atomic rotations, for example, is the essence of the theory of atomic structure-and the mathematical development goes hand in hand with the logical development as the details of the theoretical universe are gradually clarified. For some purposes, these mathematical relations are indispensable. In the study of the properties of matter, for instance, the numerical values of the properties of various substances are the primary objective, and one of the principal arguments in support of the validity of the theoretical system is that it is able to produce correct values from purely theoretical premises, mainly from the rotational displacements of the different atomic combinations, without recourse to "physical constants" obtained from empirical measurements. But for the purposes of the presentation in this volume the mathematical aspects af the theory are irrelevant, and in order to keep the text as brief and to the point as possible, no mathematical discussion has been included. If questions concerning mathematical issues arise, reference should be made to the previous books in this series listed opposite the title page.
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A significant point about motion is that we do not observe it as it actually exists; we observe it only in the context of some particular reference system. In the preceding chapter, for instance, we noted that the inward motion in space that is imparted to a material aggregate by gravitation cannot be detected in any direct manner. All that we can observe is motion toward some other aggregate. Similarly, we do not observe the scalar motion of the progression in its true character as an outward motion without direction; we see it as an outward motion of the galaxies or other objects to which it applies, but we see these objects receding from us in specific directions. Our reference system thus converts scalar motion into an apparent vectorial motion.

The manner in which a direction that is not an inherent property of the motion itself can be imparted to that motion by means of a reference system is well illustrated by the expanding balloon analogy. Fig. 2 shows a group of spots on the surface of such a balloon. The motion of these spots is inherently scalar; all spots are moving outward in all directions. But if we view this motion in the context of a three-dimensional reference system defined by the room in which the balloon happens to be located, the inherently identical motions of these four spots are all different. If spot A is resting on the floor, then spot B is moving west, spot C is moving north, while spot D is moving east. Spot A is not moving at all. What has been accomplished, so far as the motion of a spot like B is concerned, is to stop the motion in one of the dimensions and thus reduce the original scalar motion distributed over two dimensions to a one-dimensional linear motion.
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We now want to recognize that by meeting this same requirement that the spatial motion in all dimensions but one be zero, a physical object such as an atom or aggTegate of matter can have an inherently vectorial motion, one in which the direction with respect to any three-dimensional system of reference is an inherent property of the motion. We can best define the status of such a motion by considering what is necessary to produce it, if we start with the physical equivalent of nothing at all, a space-time progression in three dimensions. This situation can be represented by a triangular diagram, Fig. 3 (a) , where each vertex of the triangle indicates the speed in one of the three dimensions. The first requirement that must be met in order to reach the defined objective is to reduce the outward motion in each of two dimensions to zero by adding a unit of motion in the inward spatial direction. The resulting motion then has the pattern shown in diagram b. This is the space-time progression as we observe it in the context of our three-dimensional reference system: a uni directional linear motion directly outward from the location of observation. Here we, as observers, are in a position analogous to that of spot A on the balloon, the spot that is fixed in the reference system and thus appears to have no motion.

Another unit of motion in opposition to the progression would produce the zero level of the spatial reference system, diagram c. A finite time displacement in the active dimension then generates a linear motion in space, as in diagram d. This is the ordinary vectorial motion of our everyday experience. For present purposes no extended discussion of this type of motion is necessary, but later on we will be interested in what happens when additions of space displacement (or its equivalent) bring the speed up to the maximum limit for motion in space. From the preceding development of theory it is evident that a scalar addition to the speed would then take place, reversing the course previously described, and ultimately, if the additions continue, returning to the neutral level, the condition represented by diagram a.

Thus far we have examined three general types of motion: unidirectional linear motion (scalar and vectorial) , unidirectional rotation, and vibratory linear motion. It is evident that there is one more possible combination, and we now turn to a consideration of the fourth of the general types: vibratory rotation, a rotational motion that periodically reverses direction.

Motion of this type plays only a relatively minor role in our ordinary experience, and, in general, we do not find enough difference between rotational and linear vibrations to justify making any special distinction between the two. At the level of atoms and particles, however, the effects of a rotational vibration are altogether different from those of a linear vibration. The reason is that the atom or sub-atomic particle is basically a rotating unit. The result of adding linear translation or vibration, motion of a different nature, is to move the rotating unit, but rotational vibration is motion of the same general character as that which constitutes the basic structure of the unit to which it is applied, hence the result of adding rotational vibration is to modify the rotating unit.

As brought out in Chapter IV, the three-dimensional rotation of the atom actually consists of a two-dimensional rotation and a onedimensional rotation in the opposite scalar direction. The rotational vibration, which must necessarily oppose the rotation, may therefore be either one-dimensional or two-dimensional. The one-dimensional rotational vibration that exists in the theoretical universe can be identified with the physical phenomenon known as the electric charge. Such charges are easily produced in almost any kind of matter or sub-atomic particle, and can be detached from these units with equal ease. In a low temperature environment such as that on the surface of the earth, the electric charge therefore plays the part of a temporary appendage to the relatively permanent systems of rotational motion.

Addition of two-dimensional rotational vibration to an atom or particle has a similar effect, and since we can identify this effect with the physical phenomenon known as magnetism, we will use the same terminology and will call this rotational vibration a magnetic charge, even though the notion of a "charge" is somewhat foreign to current thinking in this area.

A charge is normally opposite in space-time direction to the rotation which it modifies, for the same reasons that apply to added motion in general. Thus a rotation with a time displacement normally takes a charge with a space displacement, and vice versa. Charges of the same space-time direction as the rotation do not exist unless they are of a forced character; that is, are originated in response to some outside influence, and where they do appear, their effects are quite different from those of an ordinary charge, as will be seen in an example shortly. Inasmuch as the rotation in the electric dimension may have either space or time displacement, electric charges of both space-time directions are possible. Two-dimensional rotation in the material universe, on the other hand, always has time displacement, simply because it is the rotational combinations with two-dimensional time displacement that we call matter. The normal magnetic charges therefore have the space direction.

The terms positive and negative are in common use with reference to both electricity and magnetism, and in order to avoid introducing additional confusion into a situation that is complicated at best, these terms will be given their usual significance whenever they are used in this work, even though this usage is somewhat inconsistent in the light of the theoretical findings. On this basis an electropositive element (which has an electric time displacement) takes a positive charge (with a space displacement) whereas an electronegative element (which has an electric space displacement) takes a negative charge (with a time displacement) . The accepted usage thus equates the "positive" and "negative" designations with the normal sequence of additions to the compound motions, rather than specifying the space-time direction of the displacement, which would, in many respects, be more convenient.

Inasmuch as a charge is a modification of the basic rotation, the number of charges that an atom can acquire, the deg7-ee of ionization, as it is called, is limited by the number of rotational units of the appropriate space-time direction that exist in the atomic structure: the number of units available for modification. Negative ionization is confined to low levels, as the effective negative rotation is never more than a few units. The limit of positive ionization is the atomic number, which represents the net total number of units of rotational time displacement in the atom.

Electric ionization may be produced by any one of a number of agencies, inasmuch as the requirement for this process is essentially nothing more than the availability of sufficient energy under appropriate conditions. In the universe at large the predominant process is thermal ionization. Thermal or heat energy is linear motion of rnaterial particles, and it is therefore space displacement. In the ionization process this linear space displacement is transformed into rotational space displacement: positive charge. As the temperature increases, more and more space displacement becomes available for ionization, and the degree of ionization rises until the atom finally reaches the point where it is fully ionized; that is, each of its units of time displacement has acquired a positive charge.

If the temperature of the fully ionized atom continues to rise, a destructive limit is ultimately reached at the point where the total space displacement, the sum of the ionization and the thermal energy, is equal to the time displacement of one of the magnetic rotational units. Here the oppositely directed rotational displacements neutralize each other, and both revert to the linear basis, destroying this portion af the atomic structure. Since the maximum ionization increases with the atomic number, the amount of thermal energy required to bring the total space displacement of a fully ionized atom up to the destructive limit is less for the heavier atoms, and the effect is to establish a temperature limit for each element that is inversely related to the atomic number. As the temperature of an aggregate rises, the heaviest elements are therefore the first to disintegrate.

The electric charge has always been regarded as one of the more mysterious natural phenomena, and the question as to just what it is and how it originates was a very live issue until the modern physicists "solved" the problem by the assertion that the question has no answer; that we will simply have to accept the charge as one of the given items in nature. Some may find it difficult, therefore, to adjust to the idea that there is actually nothing mysterious or esoteric about an electric charge; that it is simply a kind of motion. But it should be realized that we are already committed to this viewpoint just as soon as we accept the concept of a universe of motion. In such a universe all entities and phenomena are manifestations of motion, and tlie only question remaining to be answered with respect to the electric charge is just what kind of a motion it is.

As soon as we resolve this question, and arrive at an understanding that the electric charge is a one-dimensional rotational vibration, it becomes evident that a two-dimensional rotational vibration of the same nature must also exist, and that this is a magnetic charge. The fact that certain substances can be magnetized-that is, put into a state in which their magnetic behavior is analogous to the electric behavior of a charge-is well known, but the motion of an electric charge produces similar magnetic effects, and the physicists have therefore assumed that all magnetic phenomena are due to moving charges. In the light of the new information as to the nature of charges, it is evident that the same factors which produce one-dimensional (electric) ionization are also capable of producing two-dimensional (magnetic) ionization, and this magnetic ionization is therefore present wherever conditions are favorable.

As it happens, positive magnetic ionization (space displacement) which corresponds to the very common positive electric ionization, and which is normal for a material atom with its net time displacement, plays only a minor role in terrestrial phenomena, although it is more of a factor in some other locations. The reason for this seeming anomaly is the existence of a process which leads to the production of negative magnetic ionization in such quantities that the positive ionization is normally precluded. For an explanation of this process we return to the subject of sub-atomic particles.

Although hydrogen, with displacements 2-1- (1) , is the first rotational combination with an effective displacement in both rotational systems, and is therefore the first of the material elements, a series of simpler units-particles-may be formed by addition of electric space or time displacement to the rotational base and to the neutron. The particles thus derived are as follows:

Displacement	Particle
1-1-1	Unnamed
1-1-0	Neutron
1-1-(1)	Neutrino
1-0-1	Positron
1-0-0	Rotational base
1-0-(1)	Electron

As indicated in the preceding discussion, and as the displacement values in the tabulation clearly show, the sub-atomic particles are compound motions of the same general character as the atoms of matter, but do not have the effective displacement in the two rotating systems that is the characteristic property of matter. The electron, for instance, has no displacement at all (above the 1-0-0 datum) in the magnetic dimensions, and its only significant feature is one unit of space displacement in the electric dimension. In the uncharged state this particle is essentially nothing but a rotating unit of space. As such it cannot move through open space, since the relation of space to space is not motion, but it can move through matter, as matter has a net time displacement. Within matter moving electrons are known as current electricity. Like any other rotating unit, the electron (with rotational space displacement) is able to acquire an electric charge, in this case negative (time displacement) . In the charged state the particles are neutral from the space-time standpoint, and can therefore move freely in either matter or space.

The particle which is of particular interest in the present connection is the neutrino. The displacements of this particle, as given in the tabulation, are 1-1- (1) , which means that the net effective displacement of this combination is zero. With both one-dimensional and two-dimensional rotations, the neutrino is capable of taking either an electric or a magnetic charge, but on the basis of probability considerations the magnetic charge takes precedence, and under appropriate conditions the particle acquires a one-unit positive magnetic charge. This is a unit space displacement, and since the neutrino is otherwise featureless, the charged neutrino is essentially nothing but a mobile unit of space similar, in this respect, to the uncharged electron. Like the latter, it can move freely in matter, but is barred from motion through space, simply because the relation of space to space is not motion.

Neutrinos are produced in substantial quantities in some common physical processes, and since they move freely through either space or matter when in the uncharged condition, because their net displacement is zero, each body in the universe is subjected to a continuous flux of neutrinos in much the same way that it is subjected to a continuous bombardment by photons of radiation. Occasionally one of these neutrinos acquires a charge in passing through matter, and when this occurs the neutrino is trapped and cannot escape. The concentration of charged neutrinos in matter therefore builds up as the material grows older.

The difference between the situation of the charged neutrino and that of the uncharged electron should be specifically noted. While these two particles are analogous to the extent that each is a unit of space and hence can move only through matter, the uncharged electron can escape from this limitation by acquiring a charge, and a continued build-up of the concentration of these electrons also builds up forces which tend to produce the required charge, and will ultimately do so. The charged neutrino, on the other hand, can escape only by losing its charge, and since here also a continued increase in the concentration of these particles builds up forces tending to produce charges, the possibility of losing a charge becomes more remote as the concentration increases.

In order to appreciate the significance of this build-up, it is necessary to recognize that the reciprocal relation between space and time makes any motion of a particle with reference to the atom in which it is located equivalent to a reciprocal motion of the atom with respect to the particle. Inasmuch as these motions are equivalent, they reach an equilibrium. In the situation we are now considering, the rotational vibration of the neutrinos is equivalent to and in equilibrium with a reciprocal rotational vibration of the atoms in which these neutrinos are located. Since the charge of the neutrino is a magnetic space displacement, its presence causes the atom to acquire a magnetic charge with a time displacement. This is opposite in space-time direction to the usual magnetic charge, a seemingly minor point of difference, but one which, in this case, has some farreaching consequences.

The ordinary magnetic charge is foreign to the material environment, a two-dimensional space displacement in a structure whose very essence is a net time displacement, and it therefore plays only a relatively minor part in the phenomena of the material universe. The reciprocal of this charge, on the other hand, is a motion identical with the basic two-dimensional rotation of the atom, except that it is vibratory rather than unidirectional. Consequently, it adds to, and, in a sense, merges with, the atomic rotation, and has the same general effect as an equivalent addition of rotational time displacement.

Instead of exhibiting a behavior of a different kind, such as that which distinguishes an ion or a magnetized particle from a normal atom or particle, the two-dimensional charge due to the presence of the charged neutrino simply adds to the magnitudes of the normal properties of the atoms. For this reason we will not use the term “magnetic charge” in referring to this motion, but will call it a “gravitational charge.” The most conspicuous effect of the gravitational charge is to increase the mass of the atom. As noted earlier, the unit of magnetic rotation employed for convenience in the description of the structures of the atoms is equivalent to two natural units, and tbe unit of gravitational charge, which is a natural unit, is therefore one-half unit on the rotational scale. The atomic weight of the normal atom is twice the atomic number Z, and each unit of gravitational cliarge G adds one atomic weight unit. The number of units of charge that an atom may acquire is variable, and each normal atom of atomic weight 2Z is therefore accompanied by a series of isotopes with atomic weight 2Z +G.

In our local environment the various isotopes of each chemical element usually occur in fixed proportions, and the average isotopic weight of the element is recognized as the atomic weight of that element. It is evident from the foregoing discussion, however, that the existing isotopic proportions are not inherent in the structure of matter itself but are results of tbe magnetic ionization level prevailing in the local environment. In a location where the magnetic ionization level is different, the isotopic proportions will also be different.

We can deduce from the theoretical principles involved that in very young matter, where the magnetic ionization level is zero, there are no isotopes, and the atomic weight of each chemical element is its rotational value 2Z. Here, all of the rotational combinations (elements and sub-atomic particles) that are possible, all the way from the electron to element 117, are stable. In this young matter heavier elements are continually being built up from lighter ones by a process of neutron capture, and there is no destruction or degradation of an element once produced, unless the limiting atomic weight 236 (the atomic weight of the unstable element 118) is reached.

If this matter is now transferred to a region of higher ionization level, such as the surface of the earth in its present condition, some of the atoms acquire gravitational charges. From theoretical considerations it has been determined that at any given magnetic ionization level, the normal increase in mass due to the acquisition of gravitational charges in the process of attaining equilibrium with the charges of the neutrinos varies as the square of the atomic weight of the uncharged atom. A quantitative evaluation, previously published, also reveals that at a one-unit ionization level, which is the level of the local environment, the normal atomic weight increment varies from practically zero for the lowest elements to 3 for element 20, 10 for element 40, 23 for element 60, 41 for element 80, 54 for element 92, and so on. When the 54 increment is added to the 184 atomic weight of the normal atom of element 92, the total becomes 238, which is above the 236 limit. In this local environment, therefore, element 92, uranium, and all above it are theoretically unstable, and disintegrate by ejection of mass. Some of the elements immediately below number 92 can also exceed the stability limit because of a probability distribution factor similar to that which permits evaporation at relatively low average temperatures.

This disintegration process which takes place in the theoretical universe can obviously be correlated with the observed phenomenon that we call radioactivity. On first consideration, however, there appears to be a discrepancy between the theoretical characteristics of the process and those which are actually observed. The derivation of the theoretical disintegration clearly requires it to be an explosion; a single event initiated as soon as an aggregate reaches the stability limit and continuing until the process is complete. The observed radioactivity, on the other hand, seems to be a series of independent events occurring at random within the aggregate and often extending over a very long period of time. The “half-life” of some of the isotopes of uranium, for instance, runs into millions of years.

In the context of present-day physics these two descriptions are wholly irreconcilable, but in the Reciprocal System the radioactive explosion is simply the inverse of an ordinary explosion; that is, it is the same process with space and time interchanged. In an ordinary explosion, the action begins at one or more points in the aggregate and is propagated outward in space from these points at a high space velocity. Each atom of the aggregate remains in its original state until the progress of the action reaches the location in space which this atom occupies, whereupon either the atom or the molecule suddenly disintegrates. The explosion as a whole therefore takes the form of a series of individual explosions at different locations in space, initiated successively by an agency propagated through space at a finite velocity.

In a radioactive explosion, the action begins at one or more points in the aggregate and is propagated outward in time from these points at a high inverse velocity (that is, slowly) . Each atom of the aggregate remains in its original state until the progress of the action reaches the location in time which this atom occupies, whereupon it suddenly disintegrates. The explosion as a whole therefore takes the form of a series of individual explosions at different locations in time initiated successively by an agency propagated through time at a finite inverse velocity. Aside from substituting time for space, this description of the radioactive explosion is identical with the preceding description of the ordinary explosion.

As the foregoing discussion brings out, radioactivity, as we observe it, is a result of a past increase in the magnetic ionization level. The accumulation of neutrinos is continuous and irreversible, hence future increases in this level will lead to radioactive disintegration of successively lighter elements. Just as the existence of a maximum value of the combined electric ionization and thermal energy establishes a temperature limit for matter, the existence of this maximum magnetic ionization establishes an age limit.

The chapters that follow will consider the processes that cause certain aggregates of matter to exceed the age and temperature limitations, and the nature of the consequences that ensue. In preparation for these discussions we will now take a brief look at some kinds of motion that were passed over lightly in the preceding pages because they play little or no part in the familiar physical phenomena of everyday life.

It was noted in Chapter IV that the combinations of rotational motion which were identified as atoms could be either linear space displacements rotating with time displacement or linear time displacements rotating with space displacement, but that the latter do not constitute matter. We are now interested in the question as to just what they do constitute. There can be no doubt on this score. Inasmuch as they are exact duplicates of the atoms of matter except that space and time are interchanged, it is obvious that they are atoms of the inverse type of matter, related to ordinary matter in the same way that a positive charge is related to a negative charge. We might refer to them as “inverse matter” or “reciprocal matter,” but there are many criteria of inversion that are quite different from space-time direction, and in order to be specific it has seemed advisable to use a more distinctive term. The designation “cosmic” will therefore be applied to all phenomena of the inverse type that are not (like positive charges, for example) common features of the material sector of the universe. The atoms of the inverse type constitute cosmic matter. The term “anti-matter” is in common use, but it implies the negative rather than the inverse of ordinary matter, and it is therefore inappropriate.

Anti-matter has been a favorite subject of speculation in recent years, both in serious scientific literature and in science fiction. The identification of certain “anti-particles” (not aII of which are cosmic , on the basis of our definition) has, of course, given this speculation a tangible, if somewhat shaky, factual basis, as the conversion of particles of matter and their anti-particles to energy on contact with each other suggests that such contact might provide a powerful energy source. The favorite energy generation device of the science fiction heroes is one which converts matter into energy by allowing it to contact anti-matter at a controlled rate. The astronomers have been equally intrigued with the idea, and are postulating the existence of anti-matter processes wherever the generation o£ large amounts of energy appears to be going on, and are even speculating that some of the galaxies that can be observed are composed of anti-matter rather than o£ ordinary matter.

No doubt both the astronomers and the science fiction devotees will be unhappy with what the Reciprocal System has to say about the so-called anti-matter. The inverse matter, cosmic matter, as we are calling it, is subject to inverse, or cosmic, gravitation. This is not inverse in the sense that the atoms move outward rather than inward in space; it is inverse in the sense that the atoms move inward in time rather than in space. Under the influence of this inverse “as if” force, the cosmic atoms form aggregates, just as material atoms do, but these aggregates are localized in time, not in space. The constituent atoms of each aggregate are contiguous in time, but they are widely dispersed in space. We therefore encounter them in space not as galaxies, or even as aggregates of a size appropriate for fueling a space ship, but as an occasional single atom. The anti-matter energy generators will have to be put on the shelf along with the antigravity devices.

Like many other interesting subjects, the phenomena in which features of the cosmic sector of the universe impinge on our material sector are outside the scope of this presentation, but an understanding of the general relation between the two sectors will be helpful in connection with some of the issues that will be explored later. For the purpose of clarifying this relationship we will begin with ordinary vectorial motion in space, as represented by diagram d of Fig. 3, and by means of similar diagrams we will follow the course of events as space displacement, or its equivalent, is added to the motion. The previous discussion carried this process up to the point where the motion reached the neutral level, or physical zero, the point where there is no motion other than the space-time progression. The first three diagrams in Fig. 4 therefore reverse the process outlined in Fig. 3. First the equivalent space displacement is increased by reduction of the time displacement until the limit of vectorial motion is reached at unit velocity. Scalar space displacement is then added (diagram b) until the neutral condition is reached (diagram c) . The point of this present explanation is that because of the reciprocal relation between space and time, the whole process is repeated in a reciprocal manner in the region beyond the neutral level. Availability of sufficient additional space displacement enables reducing the two inactive dimensions to zero motion in time, represented by the symbol 6. To facilitate this process, the displacement in the active dimension reverts to the scalar time basis, diagram d, releasing
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space displacement to meet part of the requirements of the conversion of the inactive dimensions. Later addition of more space displacement replaces the amount diverted from the active dimension, and ultimately the speed in this dimension passes the unit level, and vectorial motion in time begins, as in diagram e. This is the normal motion of the cosmic sector, the motion of atoms and aggregates of cosmic matter.

Summarizing the foregoing, we may say that at very low levels of space displacement (equivalent to high levels of time displacement) the spatial speed in two dimensions is zero and that in the third is below unity. Here vectorial motion in space is possible. At very low levels of time displacement (equivalent to high levels of space displacement) the temporal speed in two dimensions is zero and that in the third is below unity. Here vectorial motion in time is possible. Between these two extremes there is a scalar range; that is, after the speed in space reaches unity, any further addition of space displacement-as, for instance, by release of energy in an explosionresults in a scalar addition to the previous motion. If this addition is large enough to increase the scalar speed to a point beyond the neutral level, conversion to motion in time ultimately takes place, as interactions in this zone reduce the inverse speed toward the average level of motion in time. The same considerations apply, in reverse, to motions in time which are raised to high inverse speeds by release of large amounts of inverse energy. If the neutral point is passed, conversion to motion in space ultimately results.

These points will have considerable significance in connection with the discussion in the subsequent pages, as much of the subject matter from this point on will be concerned with violent explosions and their consequences.

CHAPTER VI

The Astronomical Scene

The record of advancement of astronomical knowledge has been largely a story of the invention and utilization of new and more powerful instruments. The optical telescope, the spectroscope, the photographic plate, the radio telescope, the photoelectric cell-these, and the major improvements that have been made in their power and accuracy, are the principal landmarks in astronomical progress. It is a matter of considerable significance, therefore, that in application to astronomical phenomena the Reciprocal System of theory has the characteristics of a new instrument of exceptional power and versatility, rather than those of an ordinary theory.

Astronomy has many theories, of course, but the products of these theories are quite different from the results obtained from an instrument, inasmuch as they are determined primarily by what is already known, or is believed to be known, about astronomical phenomena. This existing knowledge, or presumed knowledge, is the raw material from which the theory is constructed, and conformity with the data already accumulated and the prevailing pattern of scientific thought is the criterion by which the conclusions of the theory are tested. The results obtained from an instrument, on the other hand, are not influenced by the current state of knowledge in the area involved. (The interpretation of the results may be so influenced, but that is another matter.) If these results conflict with accepted ideas, it is the ideas that must be changed, not the data from observation. The point now being emphasized is that the Reciprocal System, like the instrument and unlike the ordinary theory, is wholly independent of what is known or believed.

Stars and galaxies are found in the existing astronomical theories because they are put into those theories. They are aggregates of matter, they exert gravitational forces, they emit radiation, and so on, in the theoretical picture, because this information was put into the theories. They theoretically generate the energy that is required to maintain the radiation by converting matter to energy, because this, too, was put into the theories. They conform to the basic laws of physics and chemistry; they follow the principles laid down by Faraday, by Maxwell, by Newton or by Einstein, because these laws and principles were put into the theories. To this vast amount of knowledge and pseudo-knowledge drawn from the common store, the theorist adds a few assumptions of his own that bear directly on the point at issue, and after subjecting the entire mass of material to his reasoning processes he arrives at certain conclusions. Such a theory, therefore, does not see things as they are; it sees them in the context of existing observational information and existing patterns of thought. We cannot get a quasar out of such a theory until we put a quasar, or something from which, within the context of existing thought, a quasar can be derived, into the theory.

On the other hand, the existing concepts of the nature of astronomical objects cannot be put into an instrument. One cannot tell an instrument what it should see or what it should record, and it sees things as they are, not as the scientific community thinks that they ought to be. If there are quasars, the appropriate instruments see quasars. Every new instrument uncovers many errors in accepted thinking about known phenomena, while at the same time it reveals the existence of other phenomena that were not only unknown, but in many instances wholly unsuspected.

The Reciprocal System of theory is like an instrument in that it, too, is independent of existing scientific thought. Stars and galaxies composed of matter appear in the theory, but neither these objects nor the matter itself are put into the theory; they are consequences of the theory: results that necessarily follow from the only things that are put into the theory, the postulated properties of space and time. These astronomical objects that appear in the theory are subject to the basic physical laws, they exert gravitational forces, they emit radiation, and so on, not because these things were put into the theory, but because they are products of the development of the theory itself. All of the entities and relations that constitute the theoretical universe of the Reciprocal System are consequences of the fundamental postulates of the system. While we can hardly say, a priori, that this system sees things as they are, we can say that it sees things as they must be, if the physical universe is a universe of motion. If there are quasars, then this theory, like an appropriate instrument and independently of any previous theoretical or observational information, sees quasars.

In the preceding chapters we have determined how things theoretically must be in many basic areas. In some instances, the picture of the situation derived from this theory diflers very radically from the currently accepted view, but this is what we have to expect from a theory that operates in the manner of an instrument. In every case these answers derived from the theoretical development are in full agreement with all definitely established facts. So far as can be ascertained at this time, therefore, the theoretical universe defined by the new system of theory is a true and accurate representation of the actual physical universe. We may thus approach the astronomical field with confidence that here, too, the conclusions that we derive from the Reciprocal System, the conclusions as to how things must be in a universe of motion, will give us the kind of results that we get from an instrument: an accurate picture of the situation as it actually exists, independent of current thinking in the area.

According to the theory, the course of events in the astronomical world is determined mainly by the outcome, in each individual case, of the basic conflict between gravitation and the space-time progression, and the factor that makes the outcome difEerent in difEerent situations is the variation of the gravitational effect with distance. The progression of space-time originates everywhere and its magnitude is therefore constant irrespective of location, but gravitation originates at the specific location which the gravitating unit happens to occupy (momentarily) and the resulting attenuation of the gravitational effect with distance, as expressed in the inverse square law, results in a change in the relative magnitudes of the inward and outward motion as the distance increases. At unit distance the inward gravitational motion is greater than the unit motion of the space-time progression, but as our reference object moves outward the net balance of inward motion decreases, and ultimately a point is reached at which the inward and outward motions are equal. Beyond this point, the gravitational limit, as we will call it, the net motion is outward, increasing toward unit speed, the speed of light, at very great distances.

For an analogy that may be helpful in visualizing this gravitational situation we may picture a moving belt, traveling outward from a central location and carrying an assortment of cubes and balls. The outward travel of the belt represents the progression of spacetime. The cubes are analogous to the photons of radiation. Having no independent mobility of their own, they must necessarily remain permanently in the location on the belt that they occupy initiallythe same absolute location, in the terms of this work-and they therefore move outward from the point of origin at the full velocity of the belt. The balls, however, can be caused to rotate, and if the rotation is in the direction opposite to the travel of the belt and the rotational velocity is high enough, the balls will move inward instead of outward. These balls represent the atoms of matter, and the inward motion opposite to the direction of travel of the belt is analogous to gravitation. If we decrease the inclination of the belt as the distance from the central point increases, we can incorporate the inverse square relation into the analogy. Under this arrangement the closer balls will still move inward, but at some point farther out there will be an equilibrium, and beyond this point the balls will move outward in the same manner as the cubes, but at a lower speed.

It is now possible to make some further comparisons between the theoretical conclusions and the results of observation. Aggregates of matter in our immediate environment are observed to move inward in space toward each other, conforming to the inverse square relation, as required by theory. Indeed, this inward motion-gravitationis such a prominent feature locally that it is taken for granted in scientific thought that the effect is universal.

As stated in a common expression of Newton‘s Law, “Every particle of matter in the universe attracts every other particle.” But the powerful optical telescopes and other instruments now available are able to reach out to distances of billions of light years, and at these extreme distances the objects that are observed-galaxies-are not moving very slowly toward us, as they should be according to Newton‘s Law. They are moving outward away from us at very high speeds, increasing with the distance, up to a substantial fraction of the speed of light at the present observational limit.

Furthermore, the distribution of matter in the universe is altogether different from that which wauld be expected on the basis of Newton‘s Law. As expressed by A. C. B. Lovell:

The application of Newton‘s theory of gravitation, in which the attraction between bodies varies inversely as the square of the distance apart, to the large-scale structure of the universe would require that the universe had a centre in which the spatial density of stars and galaxies was a maximum. As we proceed outwards from this centre the spatial density should diminish, until finally at great distances it should be succeeded by an infinite region of emptiness.20

Einstein expresses the same thought in these words: “The stellar universe ought to be a finite island in the infinite ocean of space."21

But this is not the way things are at all. So far as can be determined from the information now available, the distribution of matter in the universe is fairly uniform from a large scale standpoint. In order to reconcile the observed situation with present-day theory some extraordinary ad hoc assumptions have had to be made: first, the assumption of an explosion of the universe as a whole, one that has hurled the galaxies into space at the enormous speeds that are now observed, and second, the assumption that space itself is distorted by the matter than it contains.

The need for any such far-fetched and fanciful assumptions is eliminated by the development of the Reciprocal System. The significant fact revealed by this theoretical development is that there are two factors involved in the distribution of matter, not just gravitation alone. The progression of space-time acts in opposition to gravitation, and by reason of the attenuation of gravitation with distance while the progression remains constant, there is a net inward motion at the shorter distances and a net outward motion at the greater distances. This accounts for both the recession of the distant galaxies and the observed distribution of matter. Within the gravitational limits matter is moving inward and aggregating into galaxies. Each of these galaxies is just what Einstein said that Newtonian gravitation in Euclidean space should produce. It is a finite island in the ocean of space within its own gravitational limits. But these galaxies-these finite islands-are receding from each other because the net motion outside the gravitational limits is outward.

The explosion theory of the origin of the galactic recession-the “big bang” theory, as it is somewhat irreverently called-provides a good example of the way in which the lack of a comprehensive general theory, and the consequent proliferation of theories of very limited scope, has prevented recognition of important aspects of physical phenomena. If we overlook a certain implausibility, the "big bang" provides an adequate explanation of the recession of the galaxies as an isolated phenomenon without relation to, or connection with, anything else. But it does not give us any inkling of a significant fact that our development of a comprehensive theory now reveals: the fact that the recession is a general phenomenon; that every unit of matter which is outside the gravitational limit of another unit is receding from that other unit. This is not apparent from observation because all units smaller than galaxies are subject to the gravitational forces of larger aggregates, and the ultimate result therefore is an equilibrium rather than a continued outward motion. Meanwhile, acceptance of a theory of limited range as an explanation of the galactic recession has prevented any theoretical investigation that might have revealed the true situation.

The recession of the smaller units accounts for a number of otherwise inexplicable relationships. The globular cluster problem is a conspicuous example. These huge aggregates of stars are obviously held together by gravitational forces, but why do the stars remain separated by immense distances on the order of light-years? Astronomy has no answer, because it cannot identify any force of the required magnitude acting in opposition to gravitation. The Reciprocal System identifies this force, and arrives at a very simple explanation of the great distances. Each star of the cluster is outside the gravitational limits of its neighbors, and it is therefore receding from them. But it cannot continue the outward motion, in the manner of the galaxies, because it is subject to the gravitational force (that is, the inward motion) of the cluster as a whole. It therefore moves outward only to a point of equilibrium where the total forces (motions) add up to zero.

This same equilibrium between the recession of the individual stars and the gravitational attraction of the aggregate also provides an explanation for the immense distances between the stars of the galaxies, a phenomenon that has hitherto not only remained unexplained, but has not even been recognized as needing an explanation. Aside from the members of multiple star systems, which theoretically have a common origin, there is no indication that any star ever comes even moderately close to another. The entire range from the relatively short separations in the multiple systems, comparable to planetary distances, out to distances measured in light-years, is completely empty. Such a wildly improbable condition cannot exist by chance. It must have an explanation, and that is what the new theoretical system provides.

But even though the stars, single and multiple, are destined to remain far apart, they do not exist in complete isolation from each other, as currently assumed. On the contrary, the fact that they are occupying equilibrium positions means that the structure of a cluster or galaxy of stars is analogous to that of a liquid. There is a certain amount of freedom of movement in the cluster, just as there is in the liquid, but any disturbance of the equilibrium conditions, either by motion of the constituent units or by outside influences, meets with resistance. Current astronomical thought does not recognize this situation. Fred Hoyle, for instance, makes these comments about possible collisions of galaxies:

Think of the stars as ordinary household specks of dust. Then we must think of a galaxy as a collection of specks a few miles apart from each other, the whole distribution filling a volume about equal to the Earth. Evidently one such collection of specks could pass almost freely through another.22

According to our findings, such a collision would be more like the impact of a stream from a fountain on the surface of the pool into which it falls. There will be a certain amount of penetration in each case, while the incoming kinetic energy is being absorbed, but in both cases the moving mass meets a wall, not a passageway. Passage of one galaxy through another is simply impossible.

The liquid-like structure of the stellar aggregate also explains why stars or groups of stars can be ejected from an aggregate by explosive forces. This is another item that current theory fails to explain.

Explosions are sudden releases of energy that "push things apart" or show as sudden increases in luminosity. It is difficult to explain the "pushing" of stars. (Page and Page) 23

When it is understood that a star cluster offers the same kind of resistance to applied forces as a viscous liquid, this "pushing" is no longer a problem, a point that will be of importance in connection with some of the items to be discussed later.

Within the range of effectiveness of the gravitational forces all units of matter move inward toward each other, and if given sufficient time must join. Various factors control the nature of the combinations; the relative directions of movement may result in orbital motion rather than actual consolidation, or the outward progression of the individual units may prevent any close approach, but inside the gravitational limits all aggregates eventually reach gravitational equilibrium. Within these limits, therefore, the aggregates of matter are continually growing. Atoms join together as particles, the particles gather into clouds, the clouds condense into stars, the stars increase in size and form groups and clusters. These aggregations grow into small galaxies, and the small galaxies become large galaxies.

In the earlier stages of this process the matter is cold, but as the dust cloud begins to contract, potential energy is gradually transformed into kinetic energy of the molecules, and the temperature of the aggregate begins to rise. At some point in this process, probably somewhere in the range in which a dense dust cloud is becoming a very diffuse star, the central temperature of the mass reaches the lower destructive limit of the heaviest atom present, and generation of energy by atomic disintegration begins.

When the star reaches gravitational equilibrium and contraction ceases, one of the two sources of energy is eliminated. The heavy element content of the star is, however, roughly proportional to the total stellar mass, which means that the production of energy from the destruction of these elements is a function of the third power of the diameter. The loss of energy by radiation, on the other hand, is a function of the surface area; that is, the second power of the diameter. The stellar temperature therefore rises as the accretion of mass continues, and this makes successively lighter elements avaiIable as fuel for the conversion process.

Since none of the heavier elements is present in more than a relatively small quantity in the usual case, the availability of an additional fuel supply due to reaching the destructive limit of one more element is not normally sufficient to cause any major change in the energy balance of the star. When the temperature corresponding to the destructive limit of the nickel-iron group of elements is reached, however, the situation is quite different. These elements are not limited to small amounts; they are present in concentrations which represent an appreciable fraction of the total mass of the star. The sudden arrival of this large quantity of material at the destructive limit activates a potential source of far more energy than the star is able to dissipate through the normal radiation mechanism. The initial release of energy from this source therefare blows the whole star apart in a tremendous explosion. Because of the relatively Iarge amount of the nickel-iron elements in the central core af the star, the explosion takes place as soon as the first portions of this material are converted into energy, and the remainder, together with the overlying Iighter matter, is dispersed by the explosion-generated velocities.

This explosion which theoretically accurs when the star reaches the destructive limit of the nickel-iron group can obviously be identified with the observed phenomenon known as a supernova. One product oi the explosion, the most visible product, is an expanding cloud of dust and gas prapelled outward from the explasion site. From the standpoint of our ordinary experience, this can be regarded as a perfectly normal result, the kind of a thing that we expect as the result of any explosion. But this stellar explosion is not just another ordinary explosion; it is an explosion of a special type. At the extremely high temperatures prevailing in the interior of the star before the explosion the atoms of matter are already moving with extremely high velocities, and when the explosion adds a large amount of kinetic energy to that already existing, the velocities of some of the atoms-a considerable fraction of the total mass in the usual case-are increased to levels beyond unity.

The nature of the resulting product can be best understood by first taking a look at what happens to the explosion products that are expanding outward in space. Ultimately the forces of expansion are overcome by gravitation and encounters with interstellar particles, and contraction then begins under the influence of the ever-present gravitational forces. In due course the cloud of particles regains the status of a star. At the stage when it first becomes visible, this star, a red giant, is still extremely diffuse. It has been picturesquely described as a red hot vacuum. But this does not mean that the matter of which it is composed is any different from the matter in the stars of the so-called “main sequence,” and no one ever suggests any such thing. It is recognized that the special characteristics of the red giant, the enormous size, the relatively low surface temperature, and the extremely low density, are all due to the existence of a large amount of emty space between the particles of matter.

Neither the mass nor the volumetric characteristics of the atoms of matter has been changed by the expansion in space. But when we measure the density, m/V, of the giant stars we include in V, because of our method of measurement, not only the actual equilibrium volume of the atoms but also the empty three-dimensional space between them, and the density of the star calculated on this basis is something of a totally different order from the actual density of the matter of which it is composed.

The situation with respect to the component of the explosion products that is moving faster than the speed of light is exactly the same, except that in this case the outward motion does not take place in space. As brought out in Chapter V, after the speed of light is reached any further increase in space displacement, or its equivalent, results in a motion in time. The particular pattern that such motion will take depends on the magnitude of the added space displacement. If this is relatively small, the speed in the two inactive dimensions remains at the spatial zero, and the motion in time is a scalar addition to the motion in space, as shown in diagram b, Fig. 4.If the added displacement is Iarge enough to carry the total speed beyond the neutral Ievel, the inactive dimensions convert to zero motion in time, and the moving object leaves the material sector, eventually reaching the situation shown in diagram e.

An object in the condition indicated by diagram b remains in the same spatial location that it would occupy at unit speed, and any further motion is not in space, but in equivalent space, the spatial equivalent of the scalar motion in time. It therefore remains as an identifiable object in space, distinguished from other objects only by a size that is abnormally small for the class of objects to which it belongs, and by the effects that accompany this reduced size: high density, high temperature, etc. While we do not have, at this stage of the development of theory, any quantitative method of evaluating the increment of speed that is acquired by the products of a supernova explosion, and thus determining theoretically whether these products will remain in the condition of diagxwam b or will continue on to that of diagram e, it is clear from observation that we can identify them as having the b status; that is, their motion in time is not sufficient to reach the neutral level.

The second component of the explosion products is thus similar to the first component in that it, too, is a cloud of dust and gas expanding outward, but it differs from the first component in that it is expanding outward in time rather than in space. The result of this expansion is a star in which the particles of matter are separated by empty time rather than by the empty space that separates the particles of the ordinary dust cloud or red giant star.

In this star the deviations from normal are just the opposite of those that we observe in the red giant. Because of the reciprocal relation between space and time, more time is equivalent to less space, hence introducing more time between the particles of matter has the same effect as decreasing the space between these particles. When we measure the volume occupied by the star in the usual manner, the results that we obtain include the effect of the reduced equivalent space, just as similar measurements of the volume of the red giant include the effect of the large amount of space between the particles. Thus, even though the actual density of the matter of which a star is composed is the same in all cases, aside from the normal effects of temperature and pressure, the measured density of the star is highly dependent on the nature of the separation between the constituent particles. The star that has expanded into time, a white dwarf, is characterized by an abnormally small volume, a very high density, and since it is radiating from a surface that is small in proportion to its mass, a high surface temperature.

When judged by terrestrial standards, the calculated densities of the white dwarfs are nothing less than fantastic, and they were originally accepted with great reluctance and only after all of the alternatives that could be conceived had been ruled out for one reason or another. In the light of the foregoing information, however, it is clear that this very high density is no more out of line than the very low density of the giant stars. The magnitude of the effect is essentially the same in both cases. In the extreme red giant the density of the star is less than the equilibrium density of matter by a factor of 105 or 106. In the extreme white dwarf the density of the star is greater than the equilibrium density by approximately the same factor. The expansion of the cloud of particles outward in time has thus accomplished the exact opposite of an expansion outward in space.

This is one of the most significant cansequences of the reciprocal relation between space and time that exists in a universe of motion, as it removes the principal obstacle that has hitherto stood in the way of an understanding of some of the most important recent discoveries in astronomy. Most of these puzzling discoveries are concerned with objects that are abnormally compact when judged by familiar standards. The white dwarf star was unique in this respect when it was first discovered, but it is now only one of many, inasmuch as a wide variety of compact objects have appeared on the scene one by one as astronomical knowledge has widened. In the case of the white dwarf, it was found possible to devise an explanation of sorts for the high density within the boundaries of conventional basic physical theory, but in order to do so it was necessary to make some extraordinary, and in some respects quite illogical, ad hoc assumptions. This merely compounded the difficulties and blocked the way to a theory of compact objects in general, as a highly artificial construct of this kind is inherently incapable of application to any situation other than that to which it was specifically fitted.

The increase in density due to outward motion in time is not limited in this manner. Any object composed of particles or other units will expand and decrease in density if those constituent units move outward spatially. Similarly, any such object will expand in time, a process that is equivalent to a contraction in space and therefore increases the density, if the constituent units move outward in time by reason of a speed in excess of that of light. Thus the same process that is responsible for the high density of the white dwarf is available to explain abnormally high density wherever we find it -in quasars, in pulsars, in galactic cores, and so on. We will make much use of this process in the subsequent pages.

CHAPTER VII

The I959 Predictions

Aside from the discussion of the pulsars and some matters of detail that have been clarified by recent studies, the essential elements of the contents of the preceding six chapters are all included in the first book of this series, *The Structure of the Physical Universe*, published in 1959. At that time the study of extra-galactic radio sources was still in its infancy; indeed only five of these sources had yet been located. The galactic collision hypothesis was still the favored explanation of the generation of the energy of this radiation; the first tentative suggestions of a galactic explosion were not to be heard for another year or two, and it would be three more years before any actual evidence of such an explosion would be found. The existence of quasars was unknown and unsuspected.

Under these circumstances the extension of a physical theory to a prediction of the existence of exploding galaxies and a description~ of the general characteristics of these galaxies and their explosion products was an unprecedented step. It is almost impossible to extend traditional theory into an unknown field in this manner, as the formulator of the conventional type of theory must have some experimental or observational facts on which to build, and where the phenomena are entirely unknown, as in this case, there are no known facts that can be utilized. A purely theoretical development, one that derives aIl of its conclusions from a set of basic premises without introducing anything from observation, is not Iimited in this manner. It is, of course, convenient to have observational data available for comparison, so that the successive steps in the development of theory can be verified as the work proceeds, but this is not actually essential. There are some practical limitations on the extent to which a theory can be developed without this concurrent verification, as human imagination is limited and human reasoning is not infallible, yet it is entirely possible to get a good general picture of observationally unknown regions by appropriate extensions of an accurate theory.

The situation which we are discussing in this present volume provides a very striking example of this kind, and before we undertake a theoretical survey of the field as it now stands after the discoveries that have been made possible by advances in equipment and techniques, it will be appropriate to examine just what the Reciprocal System of theory was able to tell us in 1959 about *phenomena that had not yet been discovered*.

We saw in Chapter IV that the structure of matter is such that it is subject to a temperature limit, and we later found that the normal course of evolution of the stars ultimately brings each of them up to that limit, causing the explosions known as supernovae. It was also brought out in the discussion of atomic structure that there is another destructive limit, in effect an age limit, the attainment of which likewise results in the disintegration of the material structure and the conversion of mass into energy. Inasmuch as aggregation is a continuous process in a universe where the controlling factor is gravitation, the oldest matter in that universe is in the location where the process of aggregation has made the most progress; that is, in the largest galaxies. Ultimately, therefore, each of the giant old galaxies must reach the second, or upper, destructive limit and terminate its existence in a violent explosion, or series of explosions.

At a time when there was no definite supporting evidence, this was a bold conclusion, particularly on the part of one who is not an astronomer and is reasaning entirely from basic physical premises. As expressed in the 1959 book,

While this is apparently an inescapable deduction from the principles previously established, it must be conceded that it seems rather incredible on first consideration. The explosion of a single star is a tremendous event; the concept of an explosion involving billions of stars seems fantastic, and certainly there is no evidence of any gigantic variety of supernova with which the hypothetical explosion can be identified.

The text then goes on to point out that some evidence of a different nature might be available, and that there actually was a known phenomenon that could well be the result of a galactic explosion, even though contemporary astronomical thought did not, at the time, view it in that light.

In the galaxy M 87, which we have already recognized as posessing some of the characteristics that would be expected in the last stage of galactic existence, we find just the kind of a phenomenon which theory predicts, a jet issuing from the vicinity of the galactic center, and it would be in order to identify this galaxy, at least tentatively, as one which is now undergoing a cosmic explosion, or strictly speaking was undergoing such an explosion at the time the light now reaching us left the galaxy.

In addition to predicting the existence of the galactic explosions, the 1959 publication also forecast correctly that the discovery of these explosions would come about mainly as the result of the large amount of radiation that would be generated at radio wavelengths. One of the prominent features of extremely violent processes affecting matter, especially if they involve atomic readjustments, is the emission of gamma rays. Both the supernova and the galactic explosion are therefore prolific sources of gamma rays. But these explosions are not confined to processes of the material type. As already explained, the matter of the stars and galaxies is so close to the dividing line just before the explosions occur that much of it is accelerated to greaterthan-unit speeds, which reverse the familiar relationships of the material sector. The gamma rays of material origin have wavelengths in the vicinity of 10‘1° cm. The natural unit of distance has been evaluated at approximately 10 5 cm, and the gamma ray wavelength is therefore in the neighborhood of low natural units. The wavelength of the inverse phenomenon, the cosmic gamma rays, is the reciprocal of 10-5 natural units, or 105 natural units, which is approximately 1 cm. Radiation at centimeter wavelengths is in the radio region, and the 1959‘ text therefore concluded that

objects which are undergoing or have recently (in the astronomical sense) undergone such (extremely violent) processes are therefore the principal sources of the localized long wave radiations which are now being studied in the relatively new science of radio astronomy.

The inverse process by which, according to the theory, the radiation at radio wavelengths is generated reverses the normal distribution of energies; that is, such a process produces what is known as a “nonthermal” distribution: one in which the energy increases as the wavelength increases. It is therefore of interest to note that this is the kind of a distribution that is observed.

The radio energy emitted by most galactic and extragalactic radio sources increases in intensity with increasing wavelength. This is described as a nonthermal distribution of energy, because it is just the opposite of the distribution expected from a body of hot gas, such as a star. (D. S. Heeschen) 24

Another point that was emphasized in the 1959 theoretical survey of the then unknown explosion phenomenon was that there would be two distinct kinds of explosion products. As in the supernova, one of these products would be accelerated to speeds greater than that of Iight, and the other would move outward in space at a speed less than that of light. Again quoting from the 1959 book:

When events of this nature take place at a regional boundary line it is logical to expect that some portion of the participating units will fail to acquire the necessary energy (or velocity) to proceed in the outward direction and will be dispersed backward. In the supernova explosion, for instance, we found that one portion of the stellar mass was blown forward into space whereas another portion was dispersed backward into time. Similarly we can expect to find a stream of particles issuing from the center of an exploding galaxy: a small replica of the large stream which is being propelled across the boundary line into time.

The predicted existence of these two different kinds of explosion products is of particular significance now, in view of the discovery of the quasars. Another item that has acquired special significance by reason of recent observational advances is the conclusion of the original theoretical study that the galactic explosion would resemble radioactivity, and hence could be expected to extend over long periods of time and to be of a periodic nature. The original description of the (at that time hypothetical) explosion process reads as follows:

The oldest stars, concentrated at the galactic center, reach the destructive limit of magnetic ionization simultaneously, just as the heaviest atoms, concentrated in the center of the star, simultaneously reach the destructive thermal limit. In each case the ensuing explosion propels the excess thermal or magnetic energy outward and the magnetic explosion is thus propagated through the mass of the galaxy just as the thermal explosion is propagated through the entire mass of the star. Although the two explosion processes are very similar in these and other respects there is one significant difference which was specifically pointed out in the original discussion of the destructive limits. The magnetic destructive limit does not involve cancellation of the magnetic rotational time displacement by an oppositely directed space displacement in the manner of the neutralization that takes place at the thermal limit, but is a result of reaching the upper zero point, the maximum possible magnetic time displacement. In other words, the galaxy and the star approach the zero limit of magnetic displacement from opposite directions. Thus the explosion of the galaxy is not a magnified supernova; it is an explosion of the inverse type: a cosmic ex~losion. In the ordinary explosion with which we are familiar a portion of the mass is converted into energy in a very short time, and this results in dispersal of the remainder of the aggregate over a large amount of space in a limited amount of hme. In the cosmic explosion space and time are reversed. Here a portion of the mass is converted into energy in a very small space, and this results in the dispersal of the remainder of the aggregate over a large amount of time in a limited amount of space.

The theoretical conclusion that the largest galaxies are the oldest, and that, as a consequence, they are the ones that explode, has not been conclusively verified as yet, but current opinion leans in this direction. It was not found possible, on the basis of the theoretical development as it stood in 1959, to specify any criteria by which the galaxies actually in the process of explosive disintegration could be recognized, but in view of the long time scale of the inverse type of explosion, it was clear that galaxies in which the explosion process is under way should be visible in substantial numbers. The following comment was made:

As the explosion proceeds a steadily increasing portion of the galaxy is dispersed into time and is lost from view. There may be some difficulty in distinguishing a galaxy which is on the way~ down from one which is on the way up, but there should be some difference in appearance which we can learn to recognize.

The work of Halton Arp that will be discussed in Chapter IX has now furnished a clue that should at least help in the identification. His conclusion is that these galaxies are “peculiar.” This is a rather indefinite term, but apparently there is a certain type of “peculiarity” that is specific enough to be a strong indication of an explosion in progress.

Summarizing the discussion thus far in this chapter, we find that the theoretical study published in 1959 made the following predictions, explicitly or by implication:

(1) That exploding galaxies exist, and would presumably be discovered sooner or later.
(2) That radio astronomy would be the most probable avenue through which the discovery would be made.
(3) That the distribution of energies in this radiation at radio wavelengths would be non-thermal, or more accurately, the inverse of thermal.
(4) That the exploding galaxies would be giants, the oldest and largest galaxies in existence.
(5) That two distinct kinds of products would be ejected from the exploding galaxies.
(6) That one product would move outward in space at a normal speed.
(7) That the other, containing the Iarger part of the ejected material, would move outward at a speed in excess of the speed of light.
(8) That this product would disappear from view.
(9) That the explosions would resemble radiaactive disintegrations, in that they would consist of separate events extending over a long period of time.
(10) That, because of the long time scale of the explosions, it should be possible to detect many galaxies in the process of exploding.

Some of these predictions have already been fulfilled. Most of the remainder receive considerable support from observational sources, and the additional confirmation required for their verification will be provided by the analysis carried out in Chapter IX. Discussion of the astronomical situation in the 1959 book was introduced by the following two paragraphs:

Theoretically it should have been possible to work out all of the foregoing development of the relations between the various components af the physical universe directly from the Fundamental Postulates by mathematical and logical processes without the necessity of checking the results against the actual properties of the existing universe at any stage of the development, and perhaps some one might have had the breadth of vision and the necessary infallibility to have accomplished the task in this manner, but as the work was actually performed each additional point that was established merely set the stage for a limited advance into new territory and a long period of checking against experimental results and reconciling the inevitable discrepancies was almost invariably required before the forward position was suf ficiently well consalidated to support a new advance.

As indicated from time to time in the preceding pages there are a number of important physical properties and relationships which had to be omitted from this initial presentation because the detailed analyses of these subjects are still incomplete, and extending onward from the major relations covered in this work there is a never ending proliferation of subsidiary phenomena. In all of these areas, however, the general nature of the answers is clearly indicated by the principles already developed, and the remaining task is that of working out the details. In another direction we face a different situation. Beyond the frontiers of our present-day knowledge lies an area in which definite correlations with observation and measurement cannot be made because the established facts are too few and their significance is too uncertain. As in the earlier stages of the development of the theories previously outlined, however, we can extend the known principles a reasonable distance into the unknown field with some degree of assurance that the conclusions reached therefrom will be substantially correct in their general aspects, although past experience suggests that accuracy in every detail is unlikely.

The advance of knowledge in the past decade has greatly increased the “degree of assurance” that the conclusions reached in the 1959 work are “substantially correct in their general aspects,” even though the galactic explosions and associated phenomena were, at the time, “beyond the frontiers” af the known. This experience is a definite verification of the contention in the foregoing paragraph that the Reciprocal System of theory is capable of arriving at correct answers in fields that are as yet unknown, as well as in the more familiar areas.

In one respect, however, the 1959 study stopped just a step short of reaching an additional conclusion of considerable importance. Inasmuch as one of the products of the galactic explosion is accelerated to speeds exceeding that which light or other radiation travels, it was concluded that this component of the explosion products would be invisible. This is the immediate result so far as the dust and gas in the products are concerned, and it is the ultimate fate of all of the material ejected at extremely high speeds, but the point that was overlooked in the original investigation is that some, possibly most, of the material ejected by the galactic explosion comes out in the form of fragments of the galaxy-that is, small galaxiesrather than as fine debris. These fragments are subject to strong gravitatianal forces, and even though the speeds imparted to them by the explosion may exceed the speed of light, the net speed after subtracting the oppositely directed gravitational speed will be less than that of light for a finite period of time. This means that although the fast-moving component of the explosion products will ultimately escape from the gravitational limitations and move off at a speed in excess of that of light, there is a substantial interim period in which these objects are accessible to observation. Here, of course, are the quasars, and this is how close the theoretical study came to identifying them years before they were found by observation; a point that is all the mare worthy of note in view of the fact that orthodox theory still has no plausible explanation of their existence. As the information presented in this chapter shows, the purely theoretical exploration of the galactic explosion phenomena carried out prior to 1959, and published in that year, well in advance of any observational discoveries in this area, supplied us with a large amaunt of information which, as nearly as we can determine on the basis of what is now known, is essentially correct. This is a very impressive performance, and it demonstrates the significant advantage of having access to a theory of the universe as a whole, independent of the accuracy-and even of the existence-of observational data in whatever area is under consideration.

In the next five chapters the results of the observations that have been made of the galactic explosion phenomena during the intervening decade will be examined in the light of this same structure of theory.

CHAPTER VIII

Quasars: The General Picture

The most obvious and most striking feature of the quasars, the point that has focused so much attention on them, is that they simply do not fit into the conventional picture of the universe. They are "mysterious," "enigmatic," "surprising," "bafHing," and so on. Thus far it has not even been possible to formulate a hypothesis as to the nature or mechanism of these objects that is not in open and serious conflict with one segment or another of the observed facts. "We have as yet no real understanding of many of the fundamental physical processes which are operating in the nuclei of galaxies and in QSO's "25 , says G. R. Burbidge. R. J. Weymann makes this comment:

The history of our knowledge of the quasi-stellar sources has been one surprise after another. Indeed, almost without exception, every new line of observational investigation has disclosed something unexpected.26

Ironically, the principal obstacles that have stood in the way of an understanding of the quasar phenomena are not difficult and esoteric aspects of nature; they are barriers that the investigators themselves have erected. In their search for scientific truth, a complicated and difficult undertaking that needs the utmost breadth of vision of which the human mind is capable, these investigators have gratuitously handicapped themselves by placing totally unnecessary and unwarranted restrictions on the allowed thinking about the subject matter under consideration. The existing inability to understand the quasars is simply the inevitable result of trying to fit these objects into a narrow and arbitrary framework in which they do not belong.

Most of these crippling restrictions on thinking result from the widespread practice of generalizing conclusions reached from single purpose theories. This practice is the most serious handicap under which physical science now labors. Many of our present-day theories, both in physics and in astronomy, are in this single purpose category, each of them having been devised solely for the purpose of explaining a single set of facts. This very limited objective imposes only a minimum of requirements that must be met by the theory, and hence it is not very difficult to forrnulate something that will serve the purpose, particularly when the prevailing attitude toward the free use of ad hoc assumptions is as liberal as it is in present-day practice. This means, of course, that the prabability that the theory is correct is correspondingly low. Such a theory, therefore, is not, in the usual case, a true representation of the physical facts; it is merely a model that represents some of the aspects of the particular physical situation. Hence there is very little chance that conclusions drawn from such a theory will be applicable to a totally different phenamenon in some unrelated field. To make matters worse, many currently accepted theories that are utilized as foundations for far-reaching generalizations do not even meet the very modest requirements that are supposed to be applicable.

Relativity theory is a good example. On the basis of this theory, the scientific Establishment has laid down the dictum: “Thou shalt not think of speeds greater than that of light.” Now let us ask, What justification is there for this far-reaching prohibition? Does it have any factual basis? No, the observations merely tell us that no higher speed can be produced by a particular kind of process. These observational results give us no inkling as to whether it is the speed itself or the capabilities of the process that is subject to a limitation. The alleged Iimitation on speed comes from the theory, not from the observed facts.

But the theory is wide open to serious question. It was developed specifically for the purpose of reconciling the theory of the compasition of velocities with the observed constant velocity of light, and since it does this much it is accepted as a “permanent property of exact science."14 Nothing more is required of it, and one of the astounding features of the situation is that it is not required to be consistent with anything else-or even with itself. If we inquire into its logical status we find that its application to motion in general is not required to be consistent with its application to uniform translational motion.

The general theory . . . discards, in a sense, the conceptual framework of its predecessor. (Peter G. Bergmann) 27

It is not required to be consistent with the accepted theory of the structure of matter.

There is hardly any common ground between the general theory of relativity and quantum mechanics. (Eugene P. Wigner) 28

It is not required to be self-consistent. The “paradoxes” that result from its application cannot be eliminated without recourse to expedients that conflict with the basic assertions of the theory.

The crucial argument of those who support Einstein (in the clack paradox controversy) automatically undermines Einstein‘s own position. (G. J. Whitrow) 29

Nor is it required to agree with any extensive set of physical facts.

There is very little experimental evidence about the features of the theory (relativity) which are peculiar to it. (J. R. Oppenheimer) 30

Consequently, it is recognized by those who actually face the issue that there is very little scientific justification for acceptance of the theory.

General relativity has hardly been tested yet; only one of its predictions has been experimentally verified . . . Its acceptance by physicists rests almost entirely on their feeling that it is inherently right but this may be a form of prejudice, rather than a reasoned judgement. (F. D. Kahn and H. P. Palmer) 31

And there is a growing tendency ta define the content of the theory in purely mathematical terms, eliminating the theoretical interpretation on which the speed limitation rests.

Einstein‘s original interpretation of the special theory of relativity is hardly ever used by contemporary physicists. (P. K. Feyerabend) 32

Using a theory of this highly questionable nature as the basis for laying down a limiting principle of universal significance is simply absurd, and it is hard to understand why competent scientists allow themselves to be intimidated by anything of this kind. There are a few signs of a coming revolt. Some investigators are beginning to chafe under the arbitrary restrictions on speed, and are trying to find ways of circumventing the alleged limit without actually offering a direct challenge to relativity itself. "Tachyons," hypothetical particles that move faster than light but have some very peculiar ad hoc properties that enable them to be reconciled with relativity theory, are now accepted as legitimate subjects for scientific speculation and experiment.33 But such halfway measures will not suffice; what science needs to do is to cut the Gordian knot and to recognize that there is no adequate justification for the assertion that speeds in excess of the speed of light are impossible. The most that can legitimately be claimed on the authority of either relativity theory or the physical observations at high velocities is that they suggest the existence of some kind of a limitation. Stretching this into a positive prohibition of higher speeds is completely unwarranted and constitutes a wholly unnecessary obstacle in the way of understanding new and unfamiliar types of phenomena such as those revealed by the discovery of the quasars.

The development of the Reciprocal System has naw made it clear that the speed of light is a limit only in a very restricted sense, and that in the universe as a whole speeds in excess of that of light, ultra high speeds, as we will call them in the ensuing discussion, are just as common as those below this level. But even without the benefit of this new information it should be evident that the idea of a speed in excess of that of light is a rational and reasonable concept that is not ruled out by anything that we actually know, and arbitrarily barring it from possible use in the explanation of phenomena that do not fit into the conventional categories is indefensible.

Meanwhile, conclusions derived from other single purpose theories are blocking the astronomers' view of additional important features of the quasars. The accepted explanation of the high density of the white dwarfs cannot be extended to aggregates of stars, and it therefore stands in the way of a realization that the high density of the quasars results from exactly the same cause. Acceptance of the "big bang" theory of the recession of the distant galaxies, a theory designed to explain one observed fact only, prevents recognition of the scalar nature of motion of the recession type, and leaves the scientific world without any explanation of the absence of quasar blueshifts.

The key to an understanding of all of the matters with which we will here be concerned, the galactic explosions, the radio galaxies, the quasars, and associated phenomena, is a realization that all these are results of reaching the upper destructive limit of matter, and that in general these results are analogous to those which were encountered in our study of the situation at the lower destructive limit. The galactic explosions are analogous to the supernova explosions, the two major components of the galactic explosion products are analogous to the two major products of the supernova explosion, and the unusual properties of the ultra high speed component of the galactic explosion products, the quasar, are analogous to the unusual properties of the ultra high speed component of the supernova explosion products, the white dwarf. The "mysterious" quasars are not so mysterious after all; they are simply the galactic equivalent of the white dwarf stars.

This answer to the quasar problem is so obvious that it should have been recognized immediately, in general if not in detail, when these objects were first discovered. It is commonly understood that the white dwarf star is a product of the supernova explosion, directly or indirectly. In this case, then, the explosion of a star has produced another star with some very peculiar properties. Evidence has recently been found that certain galaxies are also exploding, and almost simultaneously a class of objects of galactic mass with many properties similar to those of the white dwarfs has been discovered. The conclusion that these new objects, the quasars, are white dwarf galaxies follows almost automatically. But however natural this conclusion may be, the astronomers cannot accept it because they are committed to conflicting ideas that have been derived from single purpose theories and have been generalized into universal laws.

The two classes of explosive events differ in a number of details, as a galaxy is quite different from a star, and the results of reaching the upper destructive limit are not identical with the corresponding events at the lower limit, but the general situation is the same in both cases. One component of the explosion products is ejected with a speed less than that of light, and since this is the normal speed in the material sector of the universe, this product is an object of a familiar type, a rather commonplace aggregate of the units of which the exploding object was originally composed. The constituent units of a star are atoms and molecules. When a star explodes it breaks down into these units, and we therefore see a cloud of atomic, molecular, and multi-molecular particles emanating from the site of the explosion. But there is also a second component, a peculiar object known as a white dwarf star, which we identify as a similar cloud of particles that has been ejected with a speed greater than that of light and is therefore expanding into time rather than into space.

Some of the products of the galactic explosion are likewise reduced to particle size, but the basic units of which the galaxy is composed are stars, and hence the material ejected by the explosion comes out mainly in the form of stars. Instead of clouds of gas and dust particles, the galactic explosion therefore produces "clouds" of stars: small galaxies. Here, again, as in the supernova explosion, one of the products of a full-scale galactic explosion acquires a speed in excess of that of light while the other remains below this level. The galaxy traveling at normal speed is also normal in other respects, the only prominent distinguishing feature being the strong radio emission in the early stages. This product is a "radio galaxy." The high speed product is the quasar.

Motion of an object at right angles to the line of sight-proper motion, as it is known to the astronomers-can be measured, or at least detected, by observation of the change of position of the object with respect to its neighbors. Motion in the line of sight is measured by means of the Doppler effect, the change in the frequency of radiation that takes place when the emitter is moving toward or away from the observer. No proper motion of the quasars or other distant galaxies has been detected, and we may therefore conclude that the random motions of these galaxies are too small to be observable at the enormous distances that separate us from these objects. By reason of the progression of space-time, however, these galaxies are receding from each other and from the earth at high speeds that increase in direct proportion to the distance. The Doppler effect due to these speeds shifts the spectra toward the red in the same proportion. Inasmuch as an approximate value of the relation between redshift and distance (the Hubble constant) can be obtained by observation of the nearer galaxies, the redshift serves as a means of measuring the distances to galaxies that are beyond the reach of other methods.

The most notable feature of the quasars is that their redshifts are fantastically high in comparison with those of other astronomical objects. While the largest redshift thus far measured for a normal galaxy is less than .500, some of the quasar redshifts exceed 2.00, and even the lowest would be relatively high for a normal galaxy. If we assume, as most astronomers now do, that these are ordinary recession redshifts, then the quasars must be by far the most distant objects ever detected in the universe.

Our theoretical development indicates that from the standpoint of distance in space this conclusion is erroneous. In the context of the Reciprocal System of theory the recession redshift cannot exceed 1.00, as this value corresponds to the speed of light, the full speed of the progression, the level that is reached when the effect of gravi~ation becomes negligible. Even without any detailed consideration it is therefore evident that the observed quasar redshift includes another component in addition to the recession shift. From the previous account of the origin of the quasar it can readily be seen that this excess over and above the redshift due to the normal recession is a result of the extremely high speed imparted to the quasar by the galactic explosion, a speed that exceeds unity (the speed of light) and therefore has characteristics that differ significantly from those of speeds below unity, the normal range in the material sector of the universe.

In order to examine this situation in detail, let us turn back to Fig. 4, in which the various basic combinations of unidirectional motion are shown in our triangular motion diagrams. As explained in Chapter V, diagram a represents the normal motion in the material sector, the kind of motion that we encounter in our daily life. Here the two inactive dimensions of a unidirectional motion have zero space velocity. In what we have called the cosmic sector of the universe, the sector in which the normal speeds exceed that of light, the normal pattern is that shown in diagram e, where there is zero time velocity in the two inactive dimensions. To change a motion of type a to motion of type e it is necessary to convert the two inactive dimensions from zero motion in space to zero motion in time by way of a sequence such as that shown in Fig. 4, going from left to right. However, the interactions in the region beyond the neutral point (diagram c) reduce the inverse speed and accomplish the change from condition c to condition e automatically. It is only necessary, therefore, to provide enough space displacement (energy) to reach the neutral point. This requires the addition of two units of motion (equivalent to 2.00 redshift) , one in each of the two inactive dimensions.

Inasmuch as the condition of zero motion in space which exists in each inactive dimension of unidirectional motion in the material sector is the result of a negative (inward) motion acting in opposition to the inherent progression in this dimension, the effect of the motion generated by tne explosion, so far as this dimension is concerned, is to cancel the effect of the negative motion and permit the progression to take place unchecked. The added motion due to the explosian is therefore, in effect, another progression, an outward scalar motion, similar to the progression in the active dimension, and, to the extent that the motions are coincident, the redshifts are additive. Since all of this progression is outward, there are no blueshifts.

The supernova explosion is not energetic enough to give the contituent particles of the white dwarf the necessary speed to reach situation c, and that star therefore retains the zero spatial speed in the inactive dimensions, absorbing the additional energy by increasing the speed in the active dimension to a level above the speed of light (in terms of the diagram, changing T to S) . As the white dwarf loses energy by interaction with other objects it ultimately reverts back to the normal less-than-unit speed. A full-scale galactic explosion, however, is far more powerful than the supernova, and it gives the quasar enough speed to meet the two-unit requirement for entry into the cosmic sector. But this change does not take place immediately, as the speed generated by the explosion, the explosion speed, as we will hereafter call it, is subject to gravitational effects in the same manner as the normal progression, and the quasar therefore remains as a visible object in the material sector until its net explosion speed reaches two units (equivalent to a 2.00 addition to the recession redshift) .

During this interval, while the net explosion speed of the quasar is below the two-unit level, the spatial speed in the inactive dimensions must remain at zero (that is, an object cannot move translationally in space in more than one direction at a time) , and the effective portion of the explosion speed (the addition to the recession) must therefore take the form of a scalar addition to the unit recession speed. Beyond unity, motion takes place in time rather than in space, but because of the reciprocal relation, this motion in time has a space equivalent, and it is that equivalent motion in space that determines the size of the addition to the normal recession redshift that is contributed by the explosion speed.

Unit speed in time and unit speed in space are coincident; they are both defined as one unit of space per unit of time. The onedimensional separation between zero speed in space and zero speed in time is therefore two space-time (motion) units. But inasmuch as space and time are three-dimensional, the total separation amounts to 23 or 8 units. Any intervening speed can thus be expressed in either of two ways: as x units measured from zero speed in space or as 8-x units measured from zero speed in time. This is the situation that we often encounter in chemistry, where, for example, an element such as iodine has a negative valence of 1, but a positive valence of 7. In the present instance, we have found that the motion generated by the explosion must take place in time, and one unit of this motion, the smallest amount that can exist, is equivalent to seven units measured from the spatial zero, the way in which this speed in time manifests itself in the phenomena of the material sector.

The spatial equivalent of a motion in time has no dimensional limitations, as time dimensions are not related in any way to space dimensions, and the seven units are therefore divided equally (by the operation of probability) between the two spatial dimensions that are now active. The component of the explosion speed in the recession dimension is thus 3.50. If the motion of the quasar continued on this basis up to the point where the normal recession reaches unit value-that is, the point where the recessional speeds are no longer being reduced by gravitation-the total speed in the dimension of the normal recession, and the total redshift (which has the same numerical value) would be 1.00 -f- 3.50 = 4.50. Since only one dimension of the explosion speed is coincident with the normal recession, the excess redshift of the quasar at any shorter distance is proportional to the square root of the recession redshift. Thus, where the recession shift is z, the added redshift is z1/2 times the 3.5 value that corresponds to unit normal redshift. The excess quasar redshift at this point is therefore 3.5 z1 and the total redshift of the quasar is z + 3.5 z‘1**********.

On this basis, the excess redshift reaches 2.00 when the recession shift is .3265 and the total quasar redshift is 2.3265. (In the ensuing discussion the last figure will be dropped, as the redshift measurements are not currently carried to more than four significant figures.) The 2.00 explosion speed is sufficient to permit the quasar to convert to the neutral level (Fig. 4c) in the two inactive dimensions. When this conversion occurs, the gravitational effect in space disappears, and the full explosion speed (3.5) plus the full recession speed (1.0) become available to take the quasar past the neutral point and into the inverse, or cosmic, sector of the universe. The 2.326 redshift therefore constitutes a limit which cannot be exceeded (under normal conditions, at least) .

Up to the current year no redshift exceeding the theoretical limiting value by any significant amount had appeared, but quite recently the rather startling figure of 2.877 was reported for the quasar 4C 05.34. This is not necessarily in conflict with the theory, as there could conceivably be some kind of interference that would delay the conversion process that normally cuts the redshift off at the 2.00 level rather than continuing on the 3.5 z1/2 basis. For the time being, however, it will probably be advisable to regard the 2.877 figure with some degree of skepticism, particularly in view of the large margin by which it exceeds any other measured redshift.

The radiation of the quasar, like its motion, is divided between the two dimensions that are active in the ultra high speed range, and it thus has a two-dimensional distribution rather than a three-dimensional distribution such as that which takes place in three-dimensional space. Instead of following an inverse square relation, therefore, the radiation from a quasar theoretically decreases in proportion to the inverse first power of what we may call the “quasar distance,” the distance corresponding to the excess redshift. Observational data to show that the quasar radiation does, in fact, follow this theoretical first power relation will be presented in Chapter IX.

The idea of a two-dimensional distribution of radiation will no doubt create conceptual difficulties for some readers in view of the long-standing habit of looking upon space as a setting or container, even though that idea has been expressly repudiated in setting up the basic framework of the Reciprocal System. It seems advisable, therefore, to discuss the nature of this two-dimensional distribution in some detail before proceeding further with the theoretical development.

As brought out in Chapter III, the inherent relationship between location A and location B is scalar only. As a scalar quantity it can be represented one-dimensionally-that is, by a line-but in reality it has no dimensions at all. It is simply a magnitude. The expanding balloon analogy that was utilized earlier can be of considerable assistance in clarifying this situation. If points A and B are located on the balloon surface, the only inherent relation between the two is a scalar quantity expressing the separation, a quantity that changes as the balloon expands. This quantity can be represented by a line, a one-dimensional construct, but the line adds nothing to our knowledge of the situation. As long as we consider the two locations A and B only, without bringing in any kind of a reference system, the only property of the line AB is its length, a scalar magnitude. This is the same quantity as that which expressed the separation between the two locations, and we are thus right back to where we were before we started thinking in terms of the line concept.

In order to give the relation between location A and location B any significance other than that expressed by a scalar magnitude, it is necessary ta introduce a reference system, and the nature of the further relationship now perceived between the two locations depends on the particular reference system selected; that is, it is essentially a property of the reference system rather than a property of the two locations. The effect of a change of reference system on the indicated motions of the spots on the balloon surface was discussed in detail in Chapter III. As brought out there, such changes not only alter the direction attributed to a particular motion but may also affect the magnitude, even to the extent, under some circumstances, of depicting that motion as non-existent.

For reference purposes we ordinarily select a three-dimensional coordinate system; that is, we pass three perpendicular axes through point A and refer the line AB to the spatial system thus defined. What we see, then, is not things as they are in themselves, but as they appear in the context of our three-dimensional reference system. Instead of seeing location B as being related to location A merely by a magnitude representing the distance AB, we see the line AB as having a direction; that is, we locate B somewhere on the surface of a sphere with radius AB. Any motion that has no directional characteristics of its own is thus assigned a direction by our reference system. Inasmuch as this directional assignment is purely by chance, in any case where many separate motions of this nature are involved, as where photons of radiation emanate from a source in three-dimensional space, these motions are distributed over all possible directions. Under these conditions the portion of the total radiation received at point B from source A is inversely proportional to the square of the intervening distance AB.

But some motions do have directional characteristics of their own. For example, light may be emitted as a beam rather than in random directions. If this is a perfect beam (something that is hard to achieve in practice, but is theoretically possible) the amount of light received at B is independent of the distance AB. All of the emission takes place in this one direction. Obviously there is another possibility intermediate between the beam and the three-dimensional distribution. It is possible that light may be emitted under such conditions that the distribution is two-dimensional. This is the situation that theoretically exists when radiation originates in the region of ultra high speeds, where physical action takes place only in two scalar space-time dimensions and not in three-dimensional space or time. In this case all points on the circumference of a circle with radius AB are equally probable targets of the photons emanating from A, and the amount of radiation received at location B is inversely proportional to the first power of the distance AB. In a two-dimensional universe point B will always be in the plane of the radiation, but in a three-dimensional universe this plane may have any orientation in the third dimension, and the probability that point B will be located in the plane of the radiation is also inversely proportional to the first power of the distance AB.

It has already been recognized that there are aspects of the quasar radiation that are indicative of a distribution in less than three dimensions. Many investigators have suggested that this radiation might be concentrated as a beam, and in his review article on pulsars, A. Hewish refers to “beaming in two coordinates,"34 the same concept that we have derived theoretically. Hence even though the concept of a two-dimensional distribution of radiation seems rather strange in the light of current thinking, it is not entirely unprecedented. In the final analysis the validity of such a concept must be demonstrated by showing that it produces the right answers, and this will be done in the pages that follow, but an unfamiliar idea sometimes seems more palatable if it is understood that there has been previous thinking aimed in the same general direction.

If we assume that the population of ordinary galaxies is uniform in space, from the large-scale standpoint, as required by the Reciprocal System of theory, the total number of such galaxies in a volume of radius d is proportional to d3. Inasmuch as the luminosity varies as 1/d2, it then follows that the distribution of visible galaxies in distance is proportional to d1/5. The quasars also originate in threedimensional space, and their number is also proportional to d3. Because of the two-dimensional distribution of their radiation, their Iuminosity varies as l~d rather than 1/d2, but, as brought out in the preceding discussion, by reason of the random orientation of the two-dimensional radiation only ldol the total number is visible from any specific location in space. The distribution of the visible quasars in distance therefore follows the same d1/5 relation as the distribution of ordinary galaxies.

In this situation where we are examining the question as to where the visible objects are located in space, it is immaterial whether an object is invisible because its magnitude is reduced below the visibility limit by the inverse square relation or because it cannot be seen at all by reason of the orientation of the plane of the radiation. The d1/5 relation therefore holds good in both cases. When we examine the question as to the relation of the number o£ quasars to luminosity, however, this equivalence no longer exists. If we increase the power of our instruments, the object that was previously just below tbe visibility limit becomes visible, but the object that was dimensionally inaccessible remains inaccessible.

If all galaxies were equally luminous, so that the observed dif ferences in magnitude could be attributed to distance alone, the 1.5 power relation between number and distance would result in a -1.5 power relation between number N and luminosity S. It can be shown mathematically that this relation also holds good even if the luminosity is variable, as long as the variations are random. Current studies of this relationship, the log N-log S relation, as it is generally called because the pertinent data are usually shown in logarithmic form, are therefore based on the premise that the slope of the log N-log S curve will be -1.5 in a uniform Euclidean universe.

But this premise assumes a three-dimensional distribution of the radiation. In the case of the ordinary galaxies, where this assumption is valid, the total number of galaxies that are actually visible is the same as the number potentially visible; that is, sufficiently luminous to be visible. A total number proportional to d1/5 is distributed in distance in proportion to d1/5. Where there is a two-dimensional distribution in a three-dimensional universe, however, the number potentially visible is proportional to d3, but the number actually visible is less because in some instances the radiation is not directed toward the given location. For this reason the distribution of the visible objects in distance is proportional to d1/5, as previously indicated. Under these circumstances the number of visible objects to any limiting magnitude is inversely proportional to the geometric mean of these two values, and the slope of the log N-log S curve for the quasars should therefore be -2.25. This theoretical conclusion is confirmed by a study of the quasars included in the 3C (Third Cambridge) catalog which arrived at a value of -2.2.35

A great deal of attention has been paid to this relation because of its presumed relevance to cosmological issues, particularly the active contest between the "evolutionary" and "steady-state" theories of the universe. There are very few solid facts that have any relevance for cosmology, and the choice between these rival theories has had to be made largely on non-scientific grounds. In its present form the steady-state theory conHicts with the conservation laws by postulating that matter is created out of nothing, and for this reason it is philosophically unacceptable to those who regard conservation as fundamental. On the other hand, the evolutionary theories involve the existence of one or more singularities in the evolution of the universe that are beyond the reach of scientific investigation and are therefore repugnant to those who dislike mixing metaphysics with science. The counts of radio sources have consequently been hailed with enthusiasm as providing some firm support for the evolutionary theories, and for a time the steady-state advocates were in full retreat, although more recently they are beginning to reform their ranks.

These radio source counts have consistently yielded values of the log N-log S slope that exceed the -1.5 value, the most recent data indicating that the slope for all radio sources is about -1.8. Thus there are more faint sources than should be present in a steady-state universe, on the basis of a normal three-dimensional distribution of the radiation from these sources. The contention of the supporters of the evolutionary theories is that this discrepancy is an evolutionary effect, an indication that the state of affairs in the universe was different billions of years ago when the radiation that we are now receiving from the most distant objects originated. But this argument is completely dependent on the assumption that the radiation distribution is three-dimensional, and there is now ample evidence to show that this assumption is not valid in application to the quasars. Our finding that the slope of the curve for the quasars is -2.25 deprives the -1.8 value of any cosmological significance. The fact that the slope of the curve for all radio emitters is above the normal -I.5 value is now nothing more than an indication that a substantial proportion of objects of the quasar type is included in the total, which is something that we already know from observation.

Although the question as to whether we live in a steady-state or evolutionary universe is not directly involved in the chain of reasoning leading to an explanation of the quasars and associated phenomena that constitutes the primary subject matter of this volume, it may be of interest at this point to note that the development of the consequences of the postulates of the Reciprocal System leads to a universe of the steady-state type, but one that differs from the current version in that it is cyclical. Thus there is no violation of the conservation laws by creation of matter ex nihilo. In this cyclical universe the products of the destruction of the galaxies that reach the age Iimit are the raw material from which the new galaxies are eventually constructed. The new development also overcomes the other major difficulties that face the steady-state theory in its present form. It provides for the complete removal of the oldest galaxies from the system, not merely disappearance “over the time horizon,” a concept that is subject to some serious criticisms, and it alsa provides the explanation of the recession of the galaxies that is required when the “big bang” is repudiated. Current steady-state theory suggests that the appearance of new matter creates a “push” that forces the older galaxies outward, but it is totally silent as to how such a push could be accomplished.

This is a serious weakness, as present-day theory is not even able to explain how one galaxy can exert a thrust against another, or how a fragment of a galaxy could be ejected. As pointed out in Chapter VI, the prevailing theories of the structure of galaxies provide no means whereby any kind of a “push” can be exerted against a stellar aggregate in which the constituent units are separated by distances on the order of light years. Consequently, the question as to the mechanism whereby ejection of galactic fragments takes place either has to be ignored or answered by means of some far-fetched ad hoc assumptions. Our finding that the stars in a galaxy or an independent cluster occupy equilibrium positions and that, as a result, the stellar aggregate has the general characteristics of a liquid now clarifies the situation and identifies the ejection mechanism.

Addition of any substantial amount of energy to the molecular motion in a liquid would, of course, result in converting a portion of the liquid to the gaseous state, a condition in which the molecules no longer maintain their original equilibrium positions but move independently and, if confined, exert a pressure on their container. The mechanism of the galactic explosion can readily be understood if it is realized that the effect of the explosion of a number of stars in the interior of the galactic aggregate is to create what we might call a bubble of “star gas,” a situation in which the stars that have absorbed energy from the explosion have left their equilibrium positions and are moving independently in the manner of gas particles, exerting a pressure on the portions of the galaxy that surround them.

At their equilibrium points the stars are moving outward at the speed of the recession (the speed of light) and at the same time moving inward gravitationally at the same speed. The energy imparted to them by the explosions therefore increases the outward speed to a level above the recession speed, and since speeds above unity are in time rather than in space, these stars move outward in time. The pressure that is built up against the overlying material is a pressure in time, and when this pressure reaches a high enough level it blows out a section of the overlying slructure, just as an explosion in a building might throw a section of the wall out into the street. The ejected fragment is thrown outward in time, but by reason of the reciprocal relation between space and time this outward motion in time has a spatial equivalent, as pointed out earlier, and this spatial equivalent is the “quasar distance” that enters into the discussion. The energy imparted to the galactic fragment that becomes a quasar is, of course, shared between the motion of the individual stars within the fragment and the motion of the object as a whole. Indeed, a considerable portion of this energy is communicated to the constituent stars during the build-up of the explosion forces before the ejection actually takes place. We may deduce, therefore, that a substantial number of the stars in the quasar are individually moving at speeds in excess of the speed of light, and the quasar is consequently expanding in time, which means that it is contracting in equivalent space. Hence, like the white dwarfs, which are abnormally small stars, the quasars are abnormally small galaxies.

This is the peculiarity that has given them their name. They are “quasi-stellar” sources of radiation, mere points like the stars, rather than extended sources on the order of the normal galaxies. Some dimensions are beginning to emerge from recent measurements with the aid of special techniques, but this information merely confirms the fact that as galaxies they are extremely small objects. The most critical issue in the whole quasar situation, as seen in the context of current thought, is “the problem of understanding how quasars can radiate as much energy as galaxies while their diameters are some thousand times smaller."36

But this is not a unique problem; it is a replay of a record with which we are already familiar. We know that there is a class of stars, the white dwarfs, which radiate as much energy as ordinary stars while their diameters are some thousand times smaller. Now we find that there is a class of galaxies, the quasars, that has the same characteristics. All that is needed for an understanding is a recognition of the fact that these are phenomena of the same kind. It is true that the cmrrently accepted theory of the small dimensions of the white dwarfs cannot be extended to the quasars, but the obvious conclusion from this fact is that current thought in this area is wrong. In the Reciprocal System of theory the abnormally small dimensions are due to the same cause in both cases. Ultra high speeds introduce displacement in time which has the effect of reducing the equivalent space occupied by the object in question. As pointed out earlier, the quasars might well be called white dwarf galaxies.

The brightness of the quasars, another of their special characteristics, is also a result of their abnormally small size. Because of the decrease in the amount of equivalent space occupied by the quasar, the spatial area from which its radiation originates is much smaller than that of a normal galaxy of equivalent mass. Although the underlying cause- the introduction of time displacement into the structure -is the same as that which is responsible for the brightness of the white dwarf stars, the mechanism is somewhat different. Stars radiate from their entire surface, and the relatively high rate of radiation of the white dwarfs per unit of surface area is due to a high surface temperature which, in turn, is an indirect result of the high density. In a galaxy the stars are so far apart that the total radiation from the galaxy is nearly equal to the sum of the radiations from the constituent stars. Here the concept of surface temperature has no meaning, and the brightness is not a temperature phenomenon but a result of concentration of more stars into a smaller equivalent volume.

Because of the diversity of the processes that are occurring in the quasars the frequencies of the emitted radiation extend over a wide range. As explained in previous publications, thermal and other processes affecting the linear motions of atoms generate radiation which is emitted principally at wavelengths relatively close to unit space (.456 X 10~5 cm) , whereas processes such as radioactivity that alter the rotational motions of the atoms generate radiation that is mainly in wavelengths far distant from unit space. Explosions of stars or galaxies, especially the latter, cause readjustments of both the material and cosmic types, and hence these events generate both very long wave radiation (radio) and very short wave radiation (x-rays and gamma rays) as well as thermal and inverse thermal radiation. When the facilities for observation of the very short wave radiation have been improved to the level of the present radio facilities it should be possible to determine quite accurately just what is going on at any particular location by analyzing the radiation mix. In fact, some results of this kind are already possible on the basis af the optical and radio radiation alone, as will be demonstrated in Chapter X.

The question as to the origin of the large amount of energy radiated from the quasars has been a major problem ever since their discovery, but our finding that this radiation is distributed two-dimensionally rather than three-dimensionally simplifies the problem very materially. For example, if we find that we are receiving the same amount of radiation from a quasar as from a certain nearby star, and the quasar is a billion times as far away as the star, then if the quasar radiation is distributed over all three dimensions of space, as currently assumed, the quasar must be emitting a billion billion times as much energy as the star. But on the basis of the two-dimensional distribution that takes place in the theoretical universe of the Reciprocal System the quasar is only radiating a billion times as much energy as the star, and the problem of accounting for the energy production is simplified accordingly. Even in astronomy, where extremely large numbers are commonplace, a reduction of the energy requirements by a factor of a billion is very substantial. An object that radiates the energy of a billion billion (1018) stars is emitting a million times the energy of a giant elliptical galaxy, the largest aggregate of matter in the known universe (about 1012 stars) , and attempting to account for the production of such a colossal amount of energy is a hopeless task, as matters now stand. On the other hand, an object that radiates the energy of a billion (109) stars is equivalent, from the energy standpoint, to no more than a rather small galaxy.

While the new theory is thus drastically scaling down the amount of energy to be accounted for, it is at the same time providing an immense source of energy to meet the reduced requirements. The disintegration of the atom at the upper destructive limit results in complete conversion of the atomic mass into energy, and inasmuch as the magnetic ionization of the matter o£ which a star is composed is uniform throughout the mass, because of the mobility of the charged neutrinos, the explosion of a star at the upper limit is theoretically able to convert the greater part of the mass of the star into energy. It should also be noted that the quasar is not called upon to provide its own initial supply of energy. The kinetic energy that accelerates both the quasar as a whole and its constituent stars to ultra high speeds is provided by the giant galaxy from which the quasar is ejected, and all that the quasar itself has to do is to meet the subsequent energy requirements.

A point that has given considerable trouble to those who have been attempting to put the observational data on the quasars into some coherent pattern is the existence of relatively large fluctuations in the output of radiation from some of these objects in relatively short times. This imposes some limits on the sizes of the regions from which the radiation is originating, and thereby complicates the already difficult problem of accounting for the magnitude of the energy being radiated. Additional study will be required before the mechanism of these variations is understood in detail, but the theoretical conclusions reached in the preceding paragraphs make some substantial contributions toward this end by (1) drastically reducing the energy requirements, (2) showing that the quasars are very small by reason of their inherent nature, (3) revealing that motions are taking place within the quasars at speeds in excess of the speed of light, and (4) identifying the primary source of energy as a large number of separate explosions in individual stars. Each of these items helps to simplify the problem of explaining the variations, and in total they should reduce this problem to manageable dimensions. It should be noted that item (4) is sufficient, in itself, to account for the existence of the variations.

One further property of the quasars that we will want to consider at this time, because it will enter into the quantitative development in the next chapter, is the effect of the explosion speed in causing change of position in space. Here the significant factor is gravitation. In the region of speeds below 1.00, the speed of light, the effect of gravitation on a material object is to alter the spatial speed, and

Table 1

	Galaxy	**Quasar A**	**Quasar B**	**Quasar C**
Observed redshift	.050	.832	1.081	1.560
Motion in space				
Recession speed	1.000	1.000	1.000	1.000
Gravitational speed	.950	.950	.919	.840
Net redshift	.050	.050	.081	.160
Motion in equivalent space				
Explosion speed		1.000	1.000	1.400
Gravitational speed		.218	0	0
Net redshift		.782	1.000	1.400

hence the spatial position, of that object. An object which, in the absence of gravitation, would move outward at unit speed by reason of the space-time progression is slowed down by gravitation to some lower speed 1.00-X. Column 1 of Table I shows the values of these speeds (in natural units) for a galaxy with redshift .050. This galaxy is carried outward by the recession (progression) at unit speed, but there is an inward gravitational speed of .950, and the resultant net spatial speed is .050, as indicated by the redshift.

Column 2 gives the corresponding data for Quasar A, a fragment recently ejected from the galaxy of column I. This quasar is subject to the normal recession, and to the gravitational motion in the dimension of the recession, in the same manner as the galaxy of origin, and its speed (redshift) includes a component .050, equal to the net outward speed of the galaxy. But the quasar also has an additional outward motion component, the motion generated by the explosion. Because this motion takes place at ultra high speed, the retardation by gravitation is overcome much more rapidly in the dimension of the quasar motion than in the dimension of the normal recession, and while the gravitational speed opposing the recession of Quasar A is still .950, that in opposition to the explosion speed is already down to .218. The net explosion speed is then .782. and the total redshift is .782 + .050 = .832.

Inasmuch as the motion generated by the explosion takes place in time it has no effect, in itself, on the spatial position of the moving object. However, gravitation does have a spatial effect, and where a portion of the explosion speed is applied to overcoming the speed due to gravitation, the elimination of this gravitational effect modifies the net spatial speed and thus changes the spatial position of the object involved. In the case of Quasar A, an amount .218 of the total explosion speed is required for this purpose, and the net effective outward speed is reduced by this amount, but in the process of neutralizing gravitation this .218 component changes the spatial position of the quasar (something that the net effective speed, which is in time, does not do) . It can readily be seen that the spatial effect of this nature is at a maximum at the shorter distances, and it decreases as the quasar moves outward to more distant locations where gravitation is weaker. Thus we arrive at the rather surprising conclusion that the faster the quasar moves (as indicated by its redshift) the less spatial distance it travels.

Mathematical confirmation of a theoretical conclusion of this kind, one that is manifestly absurd on the basis of conventional theory, is highly significant. It does not necessarily establish the validity of the theory from which the conclusion was derived, as we cannot exclude the possibility that there may be other theories which lead to the same mathematical results, but it is positive proof that conventional theory is wrong in some essential respect. The mathematical verification of this conclusion with respect to the quasar motion that will be presented in Chapter IX, utilizing two independent lines of evidence, therefore strikes a devastating blow at the foundations of the prevailing concept of the nature of motion.

From the 3.5 z/2 relation between the quasar redshift and the redshift due to the normal recession we find that when the recession redshift reaches .081 the gravitational effect on the explosion speed is down to zero, and the excess quasar redshift is 1.00, as shown by the data for Quasar B, in column 3 of Table I. From this point on, the excess redshift of the quasar is the full equivalent of the motion in time. In the case of Quasar C, column 4, this amounts to 1.40. The absence of any gravitational effect beyond 1.00 excess redshift means that in this range the spatial speed of the quasar, relative to our location, is zero, and as we see the situation, it remains at its point of origin until the limiting .326 recession speed is reached. From probability considerations we can deduce that half of these spatially motionless objects will appear in front of the galaxy of origin. In this position the radiation of the quasar will overpower that of the galaxy, and the quasar will appear to be alone. The other half will be behind the heavily populated galactic centers from which, according to theory, they originate, and in this case the quasar radiation will be absorbed and reradiated.

As a consequence of this occlusion, the number of quasars beyond 1.00 excess redshift should be only half that which would be expected on the basis of the relation of number to distance at the lower redshift levels. Observational data confirming this point will be included with the quantitative material that will be presented in Ghapter IX. Another observable consequence should be the existence of a class of galaxies in which the nuclear regions are abnormally bright by reason of the reradiated quasar emission. We can expect to find a few such objects even where the quasars do have a small motion in space, as a certain proportion of them will be moving radially outward merely by chance. Most of the galaxies that are occluding quasars should, however, appear between the 1.00 level, where spatial motion ceases, and the 2.00 level, beyond which the quasar disappears. The corresponding recession redshifts are .08 and .326, and the theoretical objects of this class should therefore appear only in the range between these two values, except for the few chance coincidences not far below .08.

An observed class of galaxies, the so-called N type, fits the foregoing description, and can tentatively be identified with the theoretical associates of the occluded quasars.37 These N-type galaxies have the kind of abnormally bright nuclei that theoretically result from reradiating the energy received from the quasar, and have been given the “N” designation for this reason. Their spectral characteristics have many points of similarity to those of the quasars; they are distributed throughout the range of redshifts from .08 to .326 in which they should theoretically occur, with none over .326 and only a few at distances shorter than .08; and the number of such galaxies thus far identified is consistent, when due allowance is made for their lower visibility, with the number of quasars missing because of the change in the relation of number to distance above 1.00 excess redshift. While these points are by no means conclusive, they add up to a rather strong suggestion that the N galaxies should be identified with the galaxies that are theoretically occluding the missing quasars.

In any event, regardless of the specific manner in which the N type galaxies fit into the general picture, they are undoubtedly related to the quasars in some manner. The fact that the most distant N galaxy now known has a redshift of .306 is therefore highly significant. Galaxies can be, and have been, located at greater distances, and in view of the intensive search that has been made for objects with quasar-like characteristics it is quite probable that the failure to observe any N-type galaxies at distances beyond .30fi is due to the existence of a distance limit somewhere in this vicinity. This, of course, is right in line with the theoretical conclusion that the spatial distance limit for all objects with quasar characteristics, including the quasars themselves, is .326.

CHAPTER IX

Quantitative Verification

In the preceding pages it was shown that if we accept the proposition that the basic constituent of the universe is motion rather than matter, the true nature and properties of space and time can be readily determined. It was then demonstrated that a detailed development of the necessary consequences of the existence of entities with such properties produces a potentially complete theory of the universe. An immense number of qualitative and quantitative correlations between this theory and the results of observation have been carried out in basic physical areas without encountering any negative results, and this exact agreement with experience justifies the conclusion that the new theoretical structure is a true and accurate representation of physical existence in the areas that have been examined. Inasmuch as this theoretical structure is a fully integrated unit derived deductively from a single set of premises, verification of its validity in some areas is a verification of the validity of the structure as a whole. The conclusions that can be drawn from this general physical theory with respect to astronomical issues should therefore be equally as accurate as those physical conclusions that can be more easily and completely verified.

As has been brought out in the previous discussion, this presumption as to the accuracy o# the theory in application to astronomy is substantiated by a complete qualitative correspondence between the theoretical and observed characteristics of the various astronomical phenomena under consideration in this work: pulsars, quasars, white dwarf stars, galactic explosions, supernovae, the recession of the galaxies, etc. As a matter of gilding the lily, so to speak, we would like to complete the picture by making some extensive quantitative correlations similar to those that have been carried out in such areas as the properties of matter. Unfortunately, the observational data of a nature suitable for this purpose are as yet rather limited. In the case of the pulsars, the only reliable quantitative data thus far available are those relating to the pulsation periods and their characteristics. Measurements of other quantities such as "dispersion," for instance, are subject to considerable uncertainty, not only as to the accuracy of the reported values, but even as to the significance of the quantities being measured. No one is quite certain whether the "dispersion" measurements actually tell us anything.

The situation with respect to the quasars is somewhat better, but before any real progress could be made in this area it was practically essential to have some definite mathematical verification of the theoretical conclusions with respect to the nature and composition of the quasar redshifts. As mentioned in the introductory chapter, some recent work by Halton Arp of the Mt. Wilson and Palomar Observatories has now put us in a position where a conclusive quantitative verification of the redshift theory is feasible, and once this point is established, the door is open for many further quantitative correlations.

The theoretical development outlined in the preceding pages indicates that each of the oldest and largest galaxies ultimately undergoes a series of explosions in which it ejects fragments that, for a time, emit relatively large amounts of radiation at radio frequencies. Each ejection consists of two components: one fragment-small galaxy-that is quite normal, aside from the strong radio emission in its early stages, and the other, the quasar, a fragment of similar size that has some characteristics which are highly abnormal in the context of the material universe, because, according to the findings of the theoretical investigation, it is ejected with a speed greater than that of light. Like the normal recession, in which a galaxy is progressing outward at the speed of light but at the same time moving inward gravitationally, so that the net speed is less than that of light, the speed generated by the galactic explosion is a recession, a scalar outward motion, and it, too, is reduced to lower levels, for a finite period of time, by gravitation. As explained in detail in the preceding chapter, the explosion speed increases the redshift of the quasar by an amount 3.5 z1/2 where z is the normal recession redshift corresponding to the location of the quasar.

What Dr. Arp has accomplished is to identify certain instances in which there is evidence of a physical relationship between a quasar and some normal objects. Inasmuch as these physically related objects must be situated at approximately the same spatial location, this enables us to determine the magnitude of the component of the quasar redshift due to the normal recession, and hence to verify the theoretical relation between the excess redshift and the normal redshift.

Obviously, the existence of any demonstrable relation of this kind invalidates all of the explanations of the quasar redshift that are currently being given consideration in astronomical circles. Identification of the normal recession redshift as a minor component of the total shows that the prevailing view attributing the entire redshift of the quasar to the recession is incorrect. At the same time, the fact that the excess redshift is a specific function of the normal redshift rules out gravitation and other explanations of a non-recession nature. The further demonstration that an analysis of the observational data confirms the theoretical 3.5 z1/2 relation between excess and normal redshift goes a step farther and shows that the theoretical explanation is correct, thus adding a key item of quantitative evidence to the many qualitative indications of the validity of the theoretical development.

The associations identified by Dr. Arp are pairs of radio emitters located on opposite sides of "peculiar" galaxies that show visible evidence of internal disturbance. His theory is that the radio objects were ejected simultaneously in opposite directions from the central galaxy and have moved out to their present positions in the intervening time since the explosion. In some instances, more than one such pair is associated with the same central galaxy, and the assumption here is that the explosion process has been repeated. Where this has occurred it may not always be possible to correlate the product with the particular explosion, and a product of explosion I might easily be paired with the product of explosion II or explosion III. For present purposes this is immaterial as long as the kind of components required for the analysis are present, as the difference in current position between the products of successive explosions is not sufficient to introduce anything more than minor deviations from the theoretical redshift values.

In order to carry out the correlation, however, it is necessary to know the redshift of the quasar and that of at least one of the other members of the association, and any group for which this minimum amount of information is lacking must be excluded from the analysis. Any of the identified associations that contain no quasars are of no value for our purposes, regardless of the reason for their absence, and also have to be excluded. After these exclusions, which involve about half of the groups identified by Arp in 1967, there are ten associations available for analysis.

If each of these associations actually consists of a central galaxy and two or more fragments ejected from that galaxy, as Arp concludes, then all members of this association should occupy adjacent locations in space, and their recession redshifts should be approximately equal, differing only by the amounts due to the relatively small change of position since the explosion, random motion, etc. Disregarding these minor factors, a three-component association should theoretically consist of a central galaxy with redshift z, an ordinary radio galaxy with redshift z, and a quasar with redshift z +3.5 z1/2. In any case where at least one of the associates has been correctly identified, and the redshifts have been measured, we are therefore able to test the accuracy of the theoretical relation by computing the value of the quasar redshift corresponding to the appropriate value of z, and comparing it with the observed quasar shift.

Before proceeding with the comparison it will be advisable to take note of some of the conditions that must be maintained in order to assure the validity of the conclusions that are reached. If we were working with data of unquestionable reliability, this would present no problem. We would simply go ahead with the calculations without further ado. But the task that Dr. Arp has performed is one of extraordinary difficulty, and it is wholly unrealistic to expect that all of his results are correct. Indeed, the majority of his colleagues seem unwilling to concede any validity to these results, as is evident from the general preference for the "cosmological" explanation of the origin of the quasar redshifts, which attributes them entirely to the normal galactic recession and thus denies the existence of the second component that must exist if Arp's associations are physically real. We are therefore in a position where we have a double task: we must verify our basic data in the same operation by which we verify the theoretical redshift relation from these data.

In order to deal with what may be a mixture of correct and incorrect data, it is necessary to rely upon probability considerations. If the quality of the data available for analysis is poor, it might not be possible to reach any definite conclusions at all by these means, as the results that we obtain may not differ enough from random probability to be statistically significant, but if a reasonable percentage of Arp's identifications represent actual physical associations some meaningful answers can be obtained. Inasmuch as the theory being tested calls for the existence of a specific mathematical relation, any degree of conformity with that relation exceeding random probability is evidence in favor of the theoretical conclusion. A high degree of correlation much in excess of random probability is tantamount to proof, not only of the validity of the theoretical relation but also of the validity of the data that are in agreement with the theory.

The nature of the process is such, however, that some very stringent precautions are necessary in order to prevent introducing some kind of bias that would invalidate the probability argument. The most essential requirement is that the data must be random with respect to the point at issue. As the textbooks on probability emphasize, the probability principles and arguments are applicable only to random phenomena. One of the best ways to insure the necessary randomness is to utilize data that were previously compiled for some other purpose. If Dr. Arp had undertaken his work with the ultimate objective of making some such correlation as that which we are now contemplating, we could never be sure that selection effects were entirely absent, and hence the results would always be subject to a corresponding degree of uncertainty. But where his worlc was done with one purpose in view, and we are taking advantage of it for a totally different purpose, randomness of the data, with respect to the object of our inquiry, is achieved almost automatically.

One further requirement that must be observed, however, if conclusions based on probability considerations are to be beyond reproach, is that the data must be homogeneous, because unless they are homogeneous they cannot be completely random. We must therefore see that our information has all been gathered on the basis of the same set of criteria and the same processes of judgment. This means that where a process of selection is involved, we must utilize the data in the original form and exclude later additions or modifications, as it is practically impossible to maintain the original selection criteria unchanged over any substantial period of time. Even if a conscious effort is made to avoid such changeS, events taking place in the interim, and the natural evolution of thinking in the course of time, will alter the criteria in ways that are difficult to identify.
For this reason the comparisons in this chapter are all based on Arp‘s first extensive set of results, published in 1967.38 Subsequent to this publication he modified some of his original groupings and identified a considerable number of additional associations, some on the basis of the original considerations, and some on other grounds. But we cannot use this additional material in conjunction with the original, because if we do, we no longer have the homogeneous set of random data that is required to assure the validity of our probability arguments. The additional material can, of course, be used for other similar studies, and the results thereof are entitled to the same kind of consideration as the results of the present analysis, but it must be separate consideration.

It may soon be possible to duplicate the results that we have obtained from an analysis of Arp‘s original work, which was confined to objects included in the 3C (Third Cambridge) catalog of radio sources, by a similar study of another list of associations that he identified by an extension of his work to the objects listed in the Parkes (Australian) catalog, but for the present the redshifts needed for the Parkes study are not available. Although the measurement of redshifts of the radio emitters is being pursued diligently, there has been no reason, so far as those engaged on this work are concerned, for giving preference to the objects included in Arp‘s identifications, and the information required for analysis of the Parkes groups has been accumulating rather slowly. In fact, the necessary measurements are available for only two of these groups as yet. The results that we obtain from these two associations will be presented along with those of the principal study as an indication of what may be expected when more of the redshifts of the Parkes objects have been measured.

Other additions or modifications can similarly be utilized for separate studies where enough information of a homogeneous nature is available, but they cannot legitimately be combined with the original set of data. For example, Dr. Arp has found that there are several quasars located on a straight line that apparently proceeds from the galaxy NGC 520, and he considers this as evidence of physical association. But an identification of association of quasars or other objects based on linear alignment is something quite different from an identification based on the presence of two radio emitters on opposite sides of a “peculiar” galaxy, and we are not justified in taking it into account when we are undertaking to apply probability principles ta an assessment of the validity of identifications made on the latter basis. Whatever conclusions we may draw from the NGC 520 alignment are separate and distinct from those derived from the study of objects from the 3C catalog selected on an entirely different basis.

It should be noted that in cases of this kind, where we are dealing with data of unknown validity, a negative result from one set of data does not invalidate a positive result from another set of data. The reason is that a positive result is more comprehensive; it contains more information. Such a result tells us that both the theoretical relation that is being tested, and the portion of the data that conforms to that relation, are correct, whereas a negative result only tells us that either the theory or the data must be wrong. Where we have a positive result on the basis of one set of data-a definite indication that the theory is correct-and a negative result on the basis of a second set of data-an indication that something is wrong-the logical inference is that the error lies in the second set of data.

With the benefit of the foregoing understanding as to what we propose ta do and how we propose to go about it, we may now proceed to an examination of the twelve associations from Arp's 3C and Parkes studies that are available for this purpose. On beginning this

TABLE IV

Association Number	Quasar Redshift	Basis of Calculation	Excess/$z^{½}$
134	.158	C	2.78
160	.320	C	3.41
125	.595	C	3.31
148	.734	C	3.76
201	1.037	R	3.56
139	1.055	R	3.31
5055	1.659	R	5.59
Excluded			
5223	.849	C	5.3
143	1.063	C	9.1
197	2.38	C	16.7

examination, the first thing that we encounter is the necessity of some further exclusions, because the theory itself identifies some of the presumed associations as incorrect, and hence these associations cannot provide any comparisons of theory with observation. Where the theory asserts that no agreement is to be expected, a demonstrated lack of agreement is meaningless.

Dr. Arp says that he does not expect to be able to identify the central "peculiar" galaxies beyond a recession of 10,000 km/sec.39 The quasar 3C 254, with a redshift of .734, of which .039 is the normal recession, is theoretically receding at slightly over this limiting recession speed, and is therefore approximately at the point beyond which the theoretically correct central galaxy is unobservable. According to the theory, then, any identification of a central galaxy with a quasar appreciably more distant than 3C 254 (in association 148) is prima facie wrong, and a comparison of the redshifts has no significance. We can test the theory only by checking the correlation in those cases where the theory says that there should be an agreement. On this basis, the only significant correlations with the central galaxy redshift are the first four in Table II. In all of these cases the theoretical and observed values show a satisfactory agreement. (The ratio 2.78 for association 134 would not be satisfactory at a higher z value, but obviously the incidental items previously specified have a higher proportionate effect where the recession is so small.)

Beyond the point where the correct galaxy of origin becomes unobservable it is still possible that the radio galaxy associated with a particular quasar may have been correctly identified, as the radio galaxies can be detected at distances well beyond those at which the features distinguishing a “peculiar” galaxy can be recognized. The correlations in our analysis have therefore been made on the basis of the radio galaxy, if the necessary redshift measurement is available, rather than the central galaxy, far all distances greater than that of association 148, as indicated by the symbol R in the third column of the table. Here, again, however, there is an upper observational limit. It is somewhat indefinite, because of the wide range of emission energies, but the available evidence indicates that only the exceptional radio galaxy can be detected at the distance corresponding to the theoretical location of the quasar 3C 280.1 in association 5055. The legitimacy of this association is therefore open to question. Since we must exclude associations 5223, 143 and 197, together with 908 from the Parkes catalog, on the grounds previously cited, this questionable case, number 5055, is the only one in the entire list where there is a lack of agreement with the theory. All of the other associations in which the observed relation between quasar redshift and normal recession redshift could agree with the theoretical relation do show such an agreement.

The relevant data from Table II are shown graphically in Fig. 5. Each plotted point on the graph indicates the relation of the excess redshift of the particular quasar, the amount by which the quasar redshift exceeds that of a galaxy with which it is presumably associated, to the redshift of that associated galaxy. The relation to which these points should theoretically conform is shown by the diagonal line. If current astronomical opinion is correct, and the redshifts of the quasars are due to the normal recession alone, there will be no definite relation between the quasar redshift and that of the object or objects which Arp has grouped with it, and in that event the plotted points will scatter randomly, not only over the area of the graph as shown but also over a much larger area above it, extending up to values of 30 or more, as can be seen from the figures in the “excluded” group of Table II. The same will be true if the associations are real, but, as Arp himself suggests, the excess redshift is due to some cause other than motion, and hence not directly related to the normal recession.

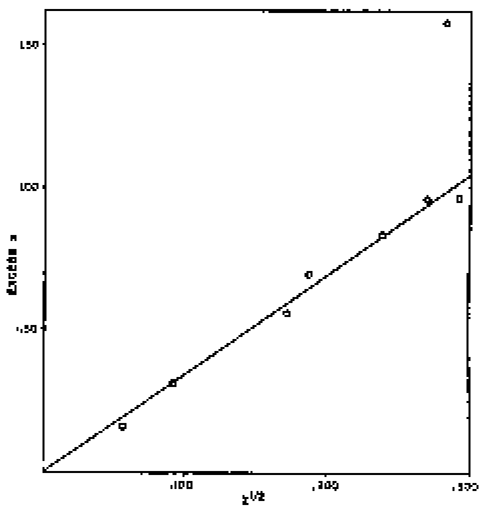


FIG. 6

But they are definitely not random. On the contrary, 6 of the 7 points (plus the one from the Parkes survey) fall essentially on the theoretical line; that is, within the margin that can be attributed to the distance the ejected objects have moved since the explosion, to random spatial motion, and other minor effects. The probability that 6 of these 7 points would fall on a straight line merely by chance is extremely remote; the probability that 6 out of 7 would fall on a straight line passing through the origin of the graph by pure chance is negligible; and the probability that 6 out of 7 would by chance fall on a straight line coinciding with a theoretically derived relationship is hardly even conceivable. The results of the test are therefore conclusive. They constitute a positive verification of the theoretical 3.5 z1/2 value of the excess quasar redshift.

Inasmuch as only one of the associations from the Parkes catalog qualified for inclusion in the test, the result in this case is not of any great significance, but the calculated ratio is 3.55, in full agreement with the theoretical value. To the extent that we are justified in taking the Parkes data into account, therefore, they support the conclusions reached by analysis of the 3C redshifts.

In addition ta confirming the validity of the theoretical explanation of the quasar redshifts, the test results also prove that Arp's identification of the central galaxy from which the quasar was ejected is correct in all cases where the central galaxy is near enough to be observable. Beyond this range, he has correctly identified the radio galaxy associated with the quasar (either specifically or as one member of a multiple association) out to the distance where detection of any but the most powerful radio galaxies becomes difficult. In other words, at least one of the associates of the quasar has been correctly identified in all cases (with only one possible exception) where these associates could have been identified. In almost all instances where aur analysis indicates that the central galaxy, or some other member of an association, has been incorrectly identified, the reason is that the correct object is too far away to be recognized.

Further confirmation of the quasar theory, highly significant because it involves a decidedly unconventional aspect of the quasar motion, can be obtained from a calculation of the speeds of the radio galaxies in those associations where all three componentscentral galaxy, quasar, and radio galaxy-have been clearly identified. There are only three cases that definitely fall in this class, as the radio galaxy in 148, the fourth of the associations within the 10,000 km~sec range, is unidentified optically, but its approximate location is known from the radio observations and the 148 system can therefore be included in the study. We can determine the theoretical spatial speed of the quasar in each of these associations from its redshift, and the ratio of the quasar speed to the speed of the radio~ galaxy from observation of the distance that each has moved since the explosion. From these two values we can then calculate the speed that the radio galaxy must have to be consistent with the theoretical speed of the quasar. If this calculated speed falls within the range in which we know the actual speed must lie, we have confirmed the theory of the spatial speed of the quasar, strange as that theory may seem in the context of conventional thought.

An approximate value of the actual speed of the radio galaxy can be obtained from a consideration of the initial speeds of its constituent stars. Just before the ejection, the individual stars in the center of the galaxy of origin are moving in random directions. The force of the explosion then superimposes on these random motions a component of motion in the outward direction. Most of the stars are thus accelerated to ultra high speeds and become part of the quasar, but some fail to attain the speed of light, and these slower stars are ejected in space as a radio galaxy. The average outward speed of these stars at the time of ejection determines the speed at which the "star gas" aggregate moves outward, and since the initial speeds are

TABLE V

Association Number	Excess Redshift	Spatial Speed	Distance Ratio	R.G. Speed
134	.155	.845	.73	.62
160	.312	.688	.91	.62
125	.566	.434	1.35	.59
148	.695	.305	2.57	.78

the tail of a probability curve in the range from 1.00 downward, the average should be somewhat above .500 and nearly the same in all cases. This is the requirement that the results of the theoretical calculations must meet in order to validate the theory.

According to this theory, the spatial component of the speed of the quasar, the component that manifests itself by changing the quasar position in space, is that portion of the speed which is required to overcome gravitation. In terms of redshift (numerically equal to the speed) it is the difference between 1.00, the speed of light, and the excess redshift of the quasar, as previously defined. The theory thus predicts a rapid decrease in the spatial speed of the quasar with increasing distance. This is completely at odds with current ideas as to the nature of motion, inasmuch as it implies that a constantly increasing proportion of the speed generated by the galactic explosion and reflected in the quasar redshift has no effect toward changing the position of the quasar in space. The results of the calculations summarized in Table III, which confirm this theoretical prediction, therefore provide some strong reinforcement for the conclusions reached in the analysis of the relation between the recession redshift and total redshift of the quasar.

Column 2 of the table gives the excess redshift af the quasar in the association identified in column l. According to the theory, the spatial speed of the quasar, the rate of change of position in space, is the difference between the excess redshift and unity, as shown in column 3. On the basis of measurements by Dr. Arp, we find the ratios of the apparent distance of the radio galaxy from the central galaxy ta the corresponding distance of the quasar from the central galaxy to be as indicated in column 4. Inasmuch as the distance traveled since the explosion is proportional to the spatial speed, the figures in column 4 also represent the relative spatial speeds of the radio galaxy and the quasar. Multiplying the spatial speed of the quasar (column 3) by the ratio of the speeds (column 4) then gives us the speed of the radio galaxy (column 5) .

These results in column 5 meet the requirements set forth earlier in the discussion; that is, they arrive at essentially the same speed for all four radio galaxies (if we make an allowance for the lack of certainty in the position of the radio galaxy in association 148) and this calculated speed is within the limits that we can establish from more direct considerations. Furthermore, a very wide range of quasar speeds is included, as the theoretical spatial speed of the quasar 3C 273 in association 134 is twice that of 3C 345 in association 125, and almost three times that of 3C 254 in association 148. The downward trend in quasar distances as the speed increases is unmistakable.

As brought out in the theoretical discussion in Chapter VIII, an important consequence of this rapid decrease in the spatial speed of the quasars is that beyond an explosion speed of 1.00, equivalent to a recession redshift of approximately .08, the spatial speed of the quasar, relative to the location from which we observe it, is zero, and from our point of view it remains at its location of origin. This means that from 1.00 ta the upper limit of 2.00 (2.326 total redshift) half of the quasars are behind the galaxies from which they originate, and are therefore not recognizable as quasars. As indicated earlier, the number of visible quasars is theoretically proportional to the 1.5 power of the distance. If we plot N against d1.5 for any random sample of the quasar population we should therefore obtain a straight line from zero to some number n at explosion speed 1.00, at which point there should be a sharp break to another straight line that reaches 1.5 n at the point on the graph corresponding to explosion speed 2.00. In Fig. 6 the quasars listed in Table 3.1 of the Burbidges‘ book *Quasi-Stellar Objects*, which includes all those for which redshifts were available at the time of publication, have been taken as the random sample. The curve is obviously in full agreement with the theoretical pattern, and the agreement is especially significant because the pattern is an unusual one. Together with the data presented in Tables II and III, this confirmation of the decrease

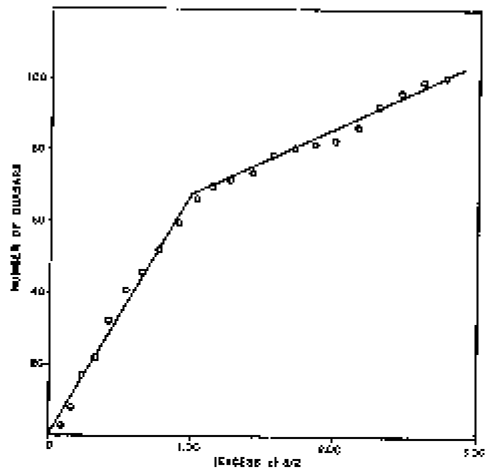


FIG. 6

in the number of visible quasars beyond 1.00 should establish the nature of the quasar motion and redshift on a firm basis.

Another independent confirmation of the quasar theory is supplied by observational data that verify the theoretical conclusion that the quasar radiation is distributed two-dimensionally and therefore varies in proportion to the inverse first power of the distance rather than following the inverse square relation that applies to phenomena originating in three dimensions. A direct comparison between quasar distance and luminosity is rather difficult to interpret because of the wide range of inherent luminosities, but where there are a number of quasars at approximately the same distance, the average luminosity of the group should approximate that of a quasar of average inherent luminosity, and by making our comparison on the basis of these group averages we can, to a large extent, eliminate the effect of the individual variability.

If we start at .200 (thereby excluding the quasar 3C 273, for reasons which will become apparent in Chapter X) and group the quasars from the Burbidge Table 3.1 in .100 redshift intervals, with some extension of the interval at the very high redshifts where necessary to keep the minimum number at 5, we obtain groups of from

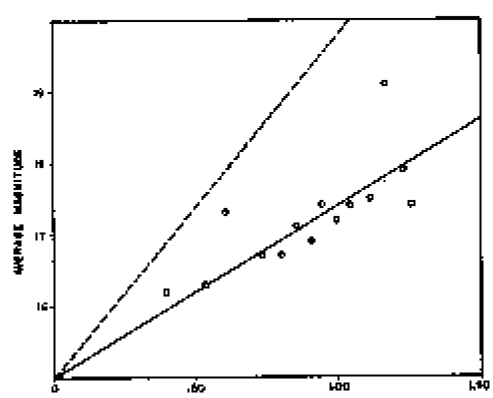


FIG. 7

5 to 10 members. A plot of the average magnitude against the logarithm of the average excess redshift of these groups then gives us the results shown in Fig. 7. The solid line in this diagram is the location of the first power relation between luminosity and excess redshift, while the broken line shows where the plotted points would fall on the basis of the inverse square relation. The verdict is clear and unequivocal: the luminosity of the quasars is inversely proportional to the first power of the quasar distance, not to the second power.

Here in this chapter is the quantitative evidence that confirms the theoretical picture of the quasars developed in Chapter VIII. We have already seen that the conclusions reached in that development are in complete qualitative agreement with the observations; now we find that the principal quantitative predictions of the theory are equally in accord with the observational data. The fact that some of these conclusions and the mathematical consequences that they predict are nothing short of outrageous in the context of conventional scientific thought makes the close correspondence between the theoretical and observed values all the more significant.

The demonstration that the quasar speed is a specific mathematical function of the recession speed verifies the theoretical conclusion that it is another motion of the recession type, subject to gravitational effects in the same manner as the recession. The theoretical assertion that this is not an ordinary spatial motion is confirmed by the mathematical proof that the greater the speed, and the redshift, of the quasar the less spatial distance it travels, until it reaches the point where the rate of change of spatial location is zero; and the theoretical assertion that it is a motion in time, with only a limited and temporary spatial effect, is confirmed by the fact that the relation between the quasar speed and the recession speed conforms to the theoretical value calculated on the time basis.

The theoretical conclusion that the motion at ultra high speeds takes place in two dimensions only enters into the relation between the explosion speed and the recession speed and therefore participates in the confirmation of the theoretical assertions regarding that relationship. Its validity is further substantiated by the analysis af the relation between quasar magnitude and distance which shows that the intensity of the radiation from a quasar is proportional to the first power rather than the second power of the distance.

The points that are thus verified are the salient features of the quasar theory as derived by development of the consequences of the pastulates of the Reciprocal System. These are the quasars that exist within the framework of a universe of motion, and the agreement with experience now demonstrates that they are likewise the quasars that exist in the actual physical universe.

CHAPTER X

Some Further Details

The two preceding chapters have drawn a general picture of the origin and evolution of the quasars, as seen in the light of the Reciprocal System of theory, and have presented sufficient evidence from observation to show that this theoretical picture is a true and accurate representation of the physical phenomena. This accomplishes the specific objectives of the work, which were, first, to produce the general explanation of the quasars that conventional theory has been unable to discover, and second, by so doing to demonstrate the ability of the Reciprocal System to account for the phenomena of the far-out regions of the universe in the same comprehensive and accurate way in which it explains the basic physical relations that have been the primary subject matter of previous publications. Further development of the details of the behavior of the quasars and associated objects is a task for the astronomers, who have the facilities for gathering the additional observational information that will be required. There are, however, a few conclusions with respect to some of these details that can be drawn from the data already available, and since these points will serve, to some degree, as further confirmation of the findings of the previous chapters, they will be discussed briefly before concluding the presentation.

In essence, this chapter will be a sort of catch-all for the things that should be said, but did not fit into the previous discussion. Because of the heterogeneous character of this material no attempt will be made at a systematic order of presentation, except that we will deal first with those items that are most directly connected with the subject matter of Chapters VIII and IX, and will then turn our attention to the various lines of inquiry that are opened up by the results of this initial phase of the supplementary investigations. It should be noted that some of the conclusions reached in this portion of the work are less firmly based than those of the two preceding chapters, and may require a certain amount of modification in the future as the accumulation of observational data contiunes,

One significant, and hitherto unexplained, item that is clarified by the theoretical development is the existence, in some quasars, of absorption spectra that are redshifted by different amounts. The stellar explosions that initiate the chain of events leading to the ejection of a quasar from the galaxy of origin reduce these stars mainly to kinetic and radiant energy. The remainder is broken down into dust and gas particles. A portion of this material penetrates into the sections of the galaxy surrounding the sector where the explosions are taking place, and when one such section is ejected as a quasar it contains some of this fast-moving dust and gas. Inasmuch as the maximum particle speeds are above the requirement for escape from the gravitational attraction of the individual stars, a part of this material ultimately assumes the form of a cloud of dust and gas around the quasar-an atmosphere, we might call it-and the radiation passes through this cloud, giving rise to absorption lines. This material is moving at nearly the same speed as the quasar itself, and the absorption redshift is therefore approximately equal to the emission redshift.

From a consideration of the various factors involved, we may deduce that in many instances the fragment of the original galaxy that is ejected as a quasar contains stars of such an advanced age that they reach the destructive limit and explode while the quasar is moving outward. This not only increases the amount of dust and gas, but may also release sufficient energy to increase the speeds of some of the particles by one or more additional units of motion in time. If one unit is added to the original single unit, the two time units that are now effective are equivalent to 8-2, or 6, space units, and the explosion speed of the particles involved therefore becomes 3 z1/2 rather than 3.5 z1/2. The quasar radiation passing through particles moving at this speed acquires an absorption spectrum with a redshift z -I- 3z1/2. Further additions to the explosion speeds of the gas and dust particles have a similar effect, the general equation applicable to n units in time being y2 (8-n) z1/2 equivalent space units. It should be noted, however, that in the general situation two of the single units of motion in time are required to increase the two-dimensional speed of objects moving faster than light by one unit. This does not apply to the first unit, since the unit speed in space due to the normal recession is also a unit sp eed in time (that is, one unit of space per unit of time) , hence one single unit of motion in time results in a change from unit one-dimensional speed to unit two-dimensional speed. Beyond this point two time units must be added to increase n by one unit. Where the available energy only amounts to the equivalent of one additional time unit we therefore find intermediate values of the absorption; i.e., 3.25 z~, and so on. The additional explosions occurring within the quasar have no efEect on the speed of the quasar as a whole, and that speed remains constant regardless of the changes that are taking place in the mo

TABLE IV

Absorption Redshift

f	*zex*	*calc.*	*obs.*
		PKS 0237-23	
3.5	.1.918		2.218 em
		2.218	2.202
3.0	1.644	1.944	1.955 possible
2.5	1.370	1.670	1.671
		1.670	1.656
			1.595 possible
2.25	1.233	1.533	1.513
2.0	1.096	1.396	1.364
		PKS 1116+12	
3.5	1.841		2.118 em
3.25	1.705	1.982	1.947
		TON 1530	
3.5	1.786		2.046 em
		2.046	2.053
3.25	1.658	1.918	1.922
		PHL 5200	
3.5	1.734		1.980 em
		1.980	1.950
3.25	1.610	1.856	1.891

tions of the constituent particles. This quasar speed never exceeds one time unit (redshift factor 3.5) because the portions of the galaxy of origin overlying the nucleus where the explosions are taking place are not able to offer sufficient resistance to permit the pressure in the interior to build up to the point where it would eject the quasar at a two-unit speed. Indeed, as we will see later, the ejection may take place even before the pressure is high enough to produce a one-unit speed in time, in which case no quasar is formed. Of course, if the galaxies of origin were larger a higher pressure would be possible, but, as pointed out earlier, the limiting age of matter establishes a galactic age limit, which automatically limits galactic size, and the existence of larger galaxies is therefore precluded.

Unfortunately, the amount of observational information available for the purpose of checking these theoretical conclusions is very limited. In fact, only one of the quasars thus far investigated has a system of absorption redshifts that is extensive enough to enable a gaod comparison with the theory. As can be seen from Table IV, however, the results of this one full-scale test of the theory are very satisfactory. Column 1 of the table gives the number of equivalent units of spatial motion added to the total quasar motion (and redshift) by the explosion speed (the redshift factor, as it was called in the preceding paragraph) . Column 2 is the corresponding excess redshift. In column 3 the recession redshift, which was subtracted from the emission redshift to arrive at the excess redshift under the conditions applying to the quasar as a whole (redshift factor 3.5) is added back again to give us the total redshift at the particle speed which is attained by reason of the energy released in the additional stellar explosions. This is the theoretical absorption redshift at the specified redshift factar. The values in column 4 are the observed redshifts,4° the emission values being distinguished by the notation "em."

As the table shows, seven absorption redshifts have been reported for the quasar PKS 0237-23, of which two are listed as only "possible." There are five theoretical absorption redshifts in the range of redshift factors from 3.5 to 2.0, and all of these are represented in the list af seven observed values, within the margin that can be ascribed to additional motion of a random character. In one instance, two of the observed redshifts are close enough to be identified with the same theoretical value. The only reported value that cannot be theoretically accounted for is one of the "possible" redshifts (1.595) .
The three other quasars included in the table have absorption redshifts that agree with the values calculated on the basis of the first increment of particle motion; that is, with a redshift factor of 3.25. All but one of the remaining absorption redshifts reported to date (1970) are close ta the emission values and thus readily understandable theoretically. The single exception is a .6128 measurement for the quasar PHL 938. If the interpretation of the spectrum that arrives at this result proves to be valid, the absorption in this instance must be due to some phenomenon other than that responsible for all of the other absorption redshifts that have thus far been measured.
Although the amount of observational information available for correlation with the theoretical deductions is small, the agreement is so close that it constitutes a rather strong case in favor of the validity af the theoretical development. But we do not have to rely entirely on this mathematical correlation, as the theoretical conclusian that the absorption phenomenon is due to additional stars reaching the destructive limit and exploding during the outward progress of the quasar can be verified by other means, inasmuch as such explosions have further consequences which we can subject to examination.

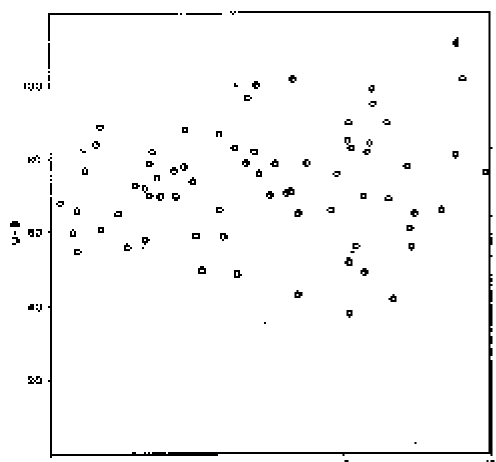
An interesting point in this connection is that the 1.891 absorption redshift given for PHL 5200 in Table IV is a relatively recent value that was not found in earlier observations of this quasar, and E. M. Burbidge suggests that a change may have occurred in the emission from this object.41 While the evidence is not sufficient to establish conclusively that such an event did take place, this is just the kind of a thing that the theory predicts: the appearance of a new lower absorption redshift either because of additional stellar explosions in the quasar or because some high-speed material already present has moved out to where it can cause absorption.

Explosions of this kind could occur relatively soon after the original ejection, as some stars of a very advanced age might be present in the ejected fragment of the original galaxy. Obviously, however, the probability of reaching a limiting age increases with time, and the older quasars are therefore the most likely to have complex absorption spectra. Because of the outward progression, the nearby regions, with the possible exceptian of those that are very near, contain only relatively young individuals, whereas the more distant regions contain not only the young quasars that have originated there, but also some older ones that have moved outward since their origin. The average age of the visible quasars thus increases with distance. Furthermore, there is an additional selection effect because the secondary explosions in the older quasars increase the intensity of the radiation and thus enable locating them at distances where the younger and fainter units cannot be detected. On the basis of these considerations we may deduce that extensive absorption systems should be found preferentially at the maximum distances.

Some observers have concluded that there is a general correlatian between distance and the presence of absorption spectra. The Burbidges, for instance, point out that 7 of the 14 quasars with z greater than 1.9 in their Table 3.1 have absorption lines, and they conclude that “at present the admittedly poor statistics suggest that the presence of absorption lines is strongly correlated with large redshift."4z Other investigators have contested this assertion. It should therefore be noted that our theoretical development indicates that absorption lines with redshifts approximately equal to the emission redshift are possible for all quasars, but that the multiple redshift systems should be confined mainly to the more dis.tant regions. In this connection it is significant that all of the quasars listed in the upper section of the Burbidge Table 3.7, the quasars with mare than one absorption line, have redshifts in the neighborhood of 2.00.

The various changes that take place during the aging of the quasars necessarily affect their spectral characteristics, and it should therefore be possible to gain some further insight into this aging process by analyzing the quasar spectra. A detailed analysis of this kind is a complex task that is beyond the scope of this work, but we can get a good indication of the general situation without having the complete picture. We can expect, for instance, that the evolution of the quasars from the early to the later stages will be accompanied by color changes. If we can identify certain specific color characteristics that vary systematically with the quasar age, this will be sufficient for present purposes, even though we are not able, as matters now stand, to produce a full explanation of the origin of these changes.

A study of the various possibilities has indicated that the color measurement most suitable for this application is the difference be. tween the quasar magnitude as measured through an ultraviolet filter and that measured through a blue filter, the U-B index, as the astronomers call it. In normal stars, those that fall on the socalled “main sequence,” color is related to the optical magnitude, and the U-B index is positive; that is, more energy is received in the blue range. The index is also positive in ordinary galaxies, which are composed mainly of such stars. By reason of the inversion that takes place when the speed of light is exceeded, the theoretical development indicates that in the quasars the color should be related to the magnitude of the radio emission rather than to the optical magnitude, and the U-B index should be negative, indicating that more energy is received in the ultraviolet range. All of the U-B values quoted herein will be negative, and should be so understood. Fig. 8 demonstrates that the U-B value is, in fact, independent of the optical magnitude; as the theory predicts. For purposes of this diagram the absalute magnitude has been calculated on the basis of the l/d relation previously established, taking an excess redshift value of 1.00 as a standard. The radio flux measurements that will be used later will be converted to the absolute basis in the same manner. There is a large scatter in the diagram, which includes the values for all of the quasars in the Burbidge Table 3.1 within the indicated magnitudes, and the amount of scatter increases somewhat with the magnitude, but it is evident that in this magnitude range,



ABSOLUTE MAGNITUDE (1.00 BASIS)

FIG. 8

the range with which we will be mainly concerned, the average U-B value is constant, and hence there is no systematic relation between U-B and optical magnitude.

In examining the other side of the theoretical proposition, the conclusion that the U-B value should be related to the radio flux, we find the situation complicated by the existence of two distinct classes of quasars, a fact that has not hitherto been recognized. For purposes of classification we will establish dividing lines at U-B = .60 and‘ at an absolute radio flux (R.F.) of 6.0 measured at 178 MHz. All quasars with U-B values of less than .60 will be placed in Class I. Those which have higher U-B but low R.F. (below 6.0) are continuous with the low U-B quasars in their properties and will also be placed in Class I. The high R.F: high U-B quasars form a discontinuous group with quite different properties, and they will constitute Class II.
Fig. 9 shows the relation between U-B and R.F. for those of the Class I quasars listed in the Burbidge Table 5.1 for which the necessary information is available. The scales of the diagram are inverted in order to conform to the conventional practice of showing increas

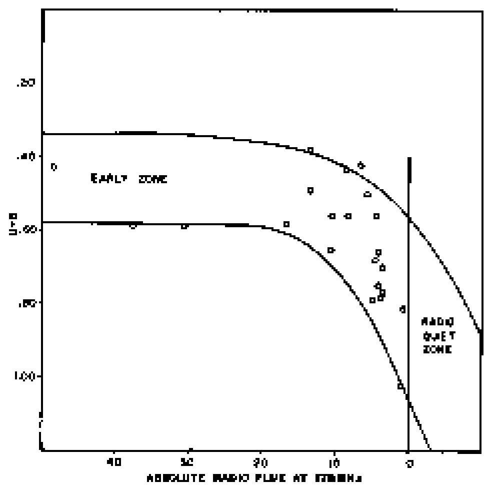


FIG. 9

ing age from left to right and decreasing activity from top to bottom. When the quasar is first ejected from the galaxy of origin its constituents are in a state of extreme activity and its radio flux is abnormally high. Only one of the quasars included in the present study is still in this very early stage. This is 3C 196, which has U-B = .43 and absolute R.F. = 48.3. Its quasar distance is .817, which makes it the most distant Class I quasar in the Burbidge table.

After the initial spurt of activity dies down to some extent, the quasar can be found in the zone designated “early” in the upper left of the diagram. As it ages and its activity drops still farther it moves to the right (toward lower R.F.) and downward (toward higher U-B) . Ultimately it passes the zero flux line and enters the radio quiet zone.

The quasars that are included in the group under consideration were originally located by radio observation and later identified optically. As Fred Hoyle puts it, “To the optical astronomer, radio data serves like a good dog on a hunt.” The capabilities of the radio facilities available at the time the observational work was done therefore

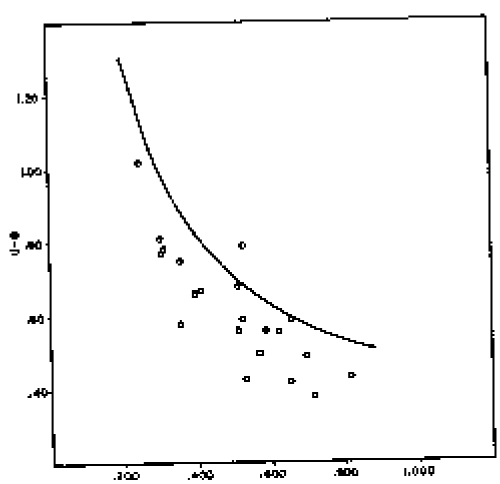


FIG. 10

establish the limit to which the observations could be carried; that is, these facilities were capable of detecting a Class I quasar of the earliest type shown on the diagram at a certain maximum quasar distance, in the neighborhood of .900. It then follows that at distances less than this maximum the same facilities were capable of detecting less powerful radio sources, and the range of observed U-B values should therefore widen as the distance decreases. Fig. 10 shows that this is true. The curved line in this diagram is a theoretical cut-off limit based on a linear relation between U-B and radio emission. This relation assumed for the purposes of the diagram is probably not accurate, but it is close enough to show that the observed Class I quasars are, in fact, subject to an observational limit of the nature required by the theory.

This limit is dependent entirely on the kind of equipment and techniques available, as the distribution of these Class I quasars in space is theoretically uniform from a large scale standpoint. As more powerful and versatile equipment becomes available, the cut-off limit will therefore move outward to greater distances. Considerable progress in this respect has already been made even in the short time since the Burbidge list which we are using for our analysis was published in 1967. At the moment, however, the fact in which we are interested is that, with the observational facilities available prior to the compilation of the 1967 list, Class I quasars-fast moving galactic fragments that are in essentially the same condition, aside from a decrease in activity, in which they were originally ejected from their galaxies of origin-could not be detected at distances greater than about .900, and those of this class that are old enough to have U-B indexes above .60 could not be detected beyond a distance of approximately .700.

The foregoing discussion is rather elementary, and it may seem to be belaboring the obvious point that stronger sources can be detected at greater distances. Its significance lies in the fact that there are other quasars with U-B indexes above .60 that can be detected beyond a quasar distance of .700. Indeed, we can follow them all the way out to the ultimate limit at 2.00. It is clear, then, that we have here a class of quasars that are not in the same condition in which they were originally ejected. In order to move into the observational range, these more distant quasars must undergo some process that releases a substantial amount of additional radiant energy at radio wavelengths.

We have already deduced that such a process exists. From a consideration of the absorption redshifts, we have concluded that secondary explosions occur in the older quasars due to the fact that some of the constituent stars reach the age that corresponds to the destructive limit. Obviously, this is just the kind of a process that is required in order to explain the emergence of a second class of quasars at distances beyond the observational limit of the Class I objects. A very important point here is that a secondary explosion of this kind is a natural sequel to the explosion in the galaxy of origin. That original explosion was initiated when the oldest stars in the galaxy reached the age limit. The stars in the ejected fragment that became the quasar were younger, but many of them were also well advanced in age, and after another long period of time some of them must also arrive at the destructive limit.

The original stellar explosions occurred outside the portion of the galaxy that was ejected as a quasar, and the radio emission from the Class I quasar is mainly a result of the extremely violent push that caused the ejection. On the other hand, the secondary explosions occur in the body of the quasar itself, and the emission from the Class II

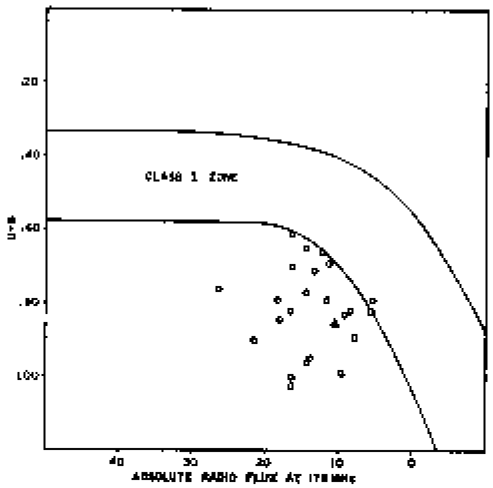


FIG. 11

quasars therefore comes directly from the exploding stars. This difference in origin is reflected in the relation between the U-B index and the radio flux, and hence we are able to utilize this relation to draw a definite distinction between the two classes. Fig. 11 is a plot of U-B vs. R.F. for the Class II quasars in the Burbidge table. As can be seen, the points representing these objects fall entirely outside the section of the diagram occupied by the quasars of Class I. There is no indication in this diagram that the Class II quasars follow any kind of an evalutionary pattern, but we will give this question some consideration later in another connection.

The quasar 3C 273 is of particular interest. This is definitely a Class II quasar, according to the criteria that have been defined, but its distance is far out of line with that of all other known objects in its class. No other Class II quasar in the group now under examination has a recession redshift of less than .052, equivalent to a quasar distance of about .800, whereas the quasar distance of 3C 273 is only .156. Ordinarily we can consider that when we measure the redshift of an object we are also determining its maximum possible age, as this age cannot be greater than the time required to move out to its present position. On this basis we would interpret the low redshift of 3C 273 as an indication that it is an unusually young Class II quasar. This could be true. It was pointed out in the earlier discussion that the secondary explosions may occur relatively soon after the original ejection, inasmuch as some of the stars in the galactic fragment ejected as a quasar may already be near the age limit at the time of ejection. Very young Class II quasars are therefore definitely possible, but the absence of Class II quasars between 3C 273 and distance .800 suggests that they must be very rare.

But 3C 273 is not necessarily young. It may be very much older than the .156 distance would indicate, as the general relation between redshift and age does not hold good at the very short distances where the magnitude of the possible random motion is comparable to that of the recession. Two galaxies that are separated by a distance in the neighborhood of their mutual gravitational limit can maintain this separation indefinitely, and the width of the zone in which the relative motion can be little or none at all is increased considerably if there is random motion with an inward component. Hence 3C 273 may have spent a long time somewhere near its present position and may be just as old as the quasars at distances around .800.

The observational evidence available at the moment is not adequate to enable making a definite decision between these alternatives, but where we have a choice between attributing a seeming abnormality to a chance coincidence that has resulted in an object of an unusual type being located very close to us, or attributing it to another kind of abnormality which we know that the object in question does possess-its proximity-the latter is clearly entitled to the preference pending the accumulation of further evidence. We therefore conclude tentatively that 3C 273 is about as old as the Class II quasars in the vicinity of distance .800. The position of 3C 273 in Fig. 11 is indicated by a triangle. As can be seen fxom the diagram, this quasar is among the weaker radio emitters in its class (although we receive a large radio flux from it because it is so close) , but so far as its properties are concerned it is not abnormal, or even a borderline case. Its proximity therefore provides a unique opportunity to observe a member of a class of objects that can otherwise be found only at great distances.

While each quasar as a whole is moving at a speed in excess of the speed of light, and the same is true of most of the constituent stars, the particles of matter of which these stars are composed are mainly moving at less-than-unit speeds in the early stages of the existence of the quasar. The radiation from these stars therefore has the normal characteristics of stellar radiation even though the ultra high speed of the quasar results in a distribution of this radiation only in two dimensions. At the time of ejection, however, the quasar also contains some matter that is moving at speeds in excess of unity, and the radiation from this matter is emitted in two dimensions only; that is, it is polarized. Some of this polarized radiation is depolarized in passing through the force fields of the surrounding stars, but a portion of it gets through unchanged, and we therefore find that an appreciable portion of the radiation received from a young Class I quasar, or from any Class II quasar, is polarized.

The percentage of polarization of the radiation as received is not an accurate measure of the magnitude of the original two-dimensional emission because of the great variability in the amount of depolarization, which depends on a number of factors, including the density and other properties of the matter present along the line of travel of the radiation. Some indication of the extent of this variability in the depolarization can be gained by examination of the polarization of the pulsed radiation received from the pulsars. For reasons which will be explained in Chapter XII, the radiation from these objects should be completely polarized as emitted, and lower polarization measurements therefore constitute evidence of depolarization.

Studies of the pulsar PSR 0833, the second youngest object of this kind thus far discovered, show the radiation as received to be 100 percent polarized,43 indicating that there is no modification on the way out of the region of origin. R. N. Manchester reports that in PSR 2022-I-51 the “polarization of the leading component is essentially complete,” and he finds the polarization of two other pulsars to be as high as 90 percent. In most instances, however, a substantial amount of depolarization is indicated. The

maximum polarization measured in the pulsed radiation from the pulsar NP 0532 in the Crab Nebula, for example, is a little over 25 percent,[45] and some of the measurements on other pulsars have produced still lower values.
It can be anticipated that there will be a similar variability in the depolarization occurring in the quasars, but because of the large number of individual radiation sources in each quasar, the average depolarization of quasar radio emission should be relatively constant. We may therefore conclude that the polarization P of the radiation received from the quasars is equal to the polarization of the emitted radiation Po multiplied by a constant factor kl, the depolarization factor; that is, P = klPo.

Radiation from thermal sources has a small component extending into the radia region, but this thermal radiation accounts for only a negligible portion of the radio emission from the quasars and associated objects. Almost all of the radiation that is received from these objects at radio wavelengths is radiation of the inverse, or cosmic, type that originates at speeds greater than that of light. Processes that would result in radiation of wavelength l/n (in natural units) if they took place at speeds less than unity produce radiation of wavelength n when they occur at speeds greater than unity. The natural unit of distance, .456 X 10 5 cm, is in the wavelength range of visible light. The cosmic equivalent of thermal radiation is therefore in the ultraviolet and x-ray range (which explains the negative U-B index of the quasars) and the cosmic gamma rays are received at radio wavelengths.

Thus it is wholly unnecessary to postulate the existence of complicated processes involving highly improbable physical conditions in order to explain this radiation. The radio emission is a perfectly normal result of a normal physical phenomenon, as any such common and ubiquitous product must be. It is a natural consequence of violent explosions that disrupt atomic structures, differing from the similar emission of x-rays and gamma rays in violent events only in that it is a product of the inverse process.

Inasmuch as motion at speeds in excess of that of light takes place in only two dimensions, radiation, which is a motion, is confined to these two dimensions, and all radiation emitted from atoms moving at these speeds is completely polarized. The total radiation from a quasar, or any other galaxy, that does not contain any appreciable number of very old stars, is practically constant over the relatively short active lifetime of a Class I quasar. The amount of polarized radiation from an average quasar of this class at any time during its active period is therefore proportional to the polarization; that is, Ep = k2Po. We have previously found that Po = P/kl. Substituting the latter value for Po in the energy equation, we then obtain EP = (k2/k1) P = kP. The average quasar has a specific distribution of radiation frequencies, and for such a quasar this energy equation is applicable to any given range of frequencies, as well as to the total radiation. We thus arrive at the conclusion that the energy received from a Class I quasar at radio wavelengths, the radio flux, is proportional to the polarization.

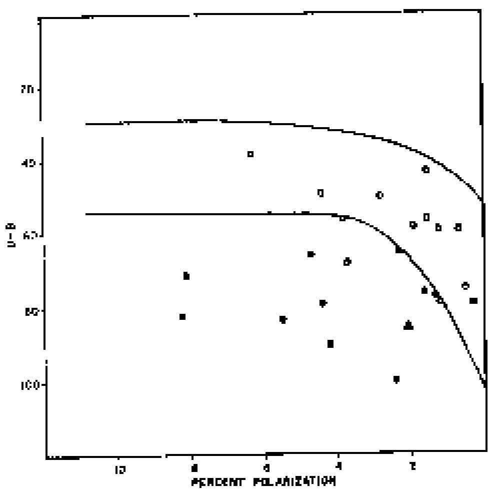


Fig. 12

A direct comparison between these two quantities produces results that are consistent with this theoretical conclusion, but because of the large scatter in the diagram due to uncertainties in the polarization measurements and the lack of integrated values of the polarization, interpretation of the results obtained in this manner is somewhat ambiguous. The best way of establishing the validity of the theoretical finding appears to be a demonstration that the decrease in polarization of the Class I quasars with increasing age (as indicated by the U-B index) follows the same path as the decrease in radio flux (Fig. 9) .

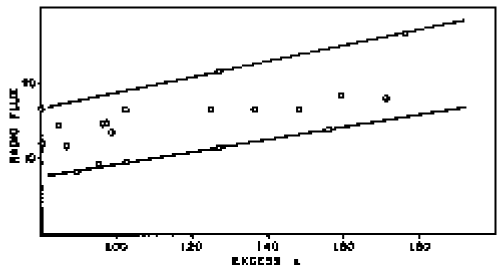
Fig. 12 duplicates Figs. 9 and 11, substituting polarization for radio flux. It covers all of the quasars from the 3C catalog listed in the Burbidge Table 5.1 for which the necessary data are available. Polarization values are not given in the Burbidge work and they have therefore been taken from other sources, mainly the measurements at 21.2 cm reported by Bologna, et a1,46 In view of the large variations in the polarization measurements by different investigators it has seemed advisable to have the benefit of a second set of values, and since no other measurements at the same wavelength are available, the results at 6 cm reported by Sastry, et a1,47 have been averaged in with the 21.2 cm values in the following manner: The average polarization at 21.2 cm was compared to that at 6 cm for those quasars on which both measurements are available, and it was found to be .673 of the 6 cm average. The 6 cm values as reported were therefore reduced by the factor .673 and then averaged with the corresponding 21.2 cm values for purposes of Fig. 12. Where no 6 cm measurement was reported, the 21.2 result was utilized without modification. This method of combining the two sets of data is based on the assumption that the radio spectra of the quasars conform to a general pattern within a reasonable margin of variation. This should be true for all but the exceptional objects, and the combination should therefore give us values which are more reliable than either set of observations individually.

Within the accuracy of the observations, the evolutionary path of the Class I quasars in this diagram, represented by the open circles, is identical with the trend of the R.F. values for these same quasars in Fig. 9. In the early stages, when the U-B index is low, the efEects of the forces exerted during the ejection are still very much in evidence, the polarization is consequently high, and the quasar is located in the upper left of the diagram. As it ages and the violent activity subsides, the polarization decreases, moving the quasar toward the right, and the U-B index increases, moving the quasar downward on the diagram, following the same course as the radio flux in Fig. 9.

The Class II quasars, represented by the filled circles, occupy a different region of the diagram, quite distinct from the Class I region, just as they did in Fig. 11. Actually two of the quasars are on the wrong side of the dividing line, but some discrepancies can be expected, in view of the uncertainties in the polarization measurements. Both of the deviant cases are in the group for which we have only the 21.2 cm measurement. As in Fig. 11, the quasar 3C 273 occupies a normal position in the diagram, indicated by a triangle. This location is well away from the boundary line, where there is no doubt as to the proper classification of the quasar.
Like the previous comparison of R.F. and U-B in Fig. 11, the Fig. 12 diagram gives no indication of a Class II evolutionary pattern, except that the cut-ofE line at the right of the diagram drops sharply as it approaches zero polarization. This lack of a definite trend is quite understandable. In Class I there is a specific initial point. At the time of ejection, the violent activity is at a maximum, and as the quasar ages this activity gradually decreases, together with the visible indicators of that activity. In Class II, however, the activity is not initiated by a single event, but by a series of explosions of individual stars which extends over a very long period of time. We have seen that, aside from possible exceptions such as 3C 273, the explosions do not occur in any substantial numbers earlier than the age corresponding to a quasar distance of about .800, but they can begin at any later time. The radiation from the Class II quasars therefore consists of a mixture of components of different ages.

It is possible, nevertheless, to arrive at some conclusions about the evolution of these objects on the basis of the theoretical deductions that have been verified in application to other phenomena, including the Class I quasars. The polarization, as we have seen, is an indication of the amount of violent activity, and for the Class II quasars a relatively high polarization means that the large-scale series of stellar explosions which raises the quasar from the radio-quiet to the Class II status has only recently begun. We may therefore distinguish the recent arrivals in Class II from those of longer standing by their higher polarization. Inasmuch as the Class II quasars do not make their appearance at all (with the usual exception of 3C 273) befare a quasar distance of about .800, we can expect that the distance range immediately above .800 will contain a preponderance of quite recent entries into Class II. This expectation is borne out by the fact that three of the four quasars below a distance of .900 have polarizations well above the average for the total group included in the study, and the quasar with the shortest distance also has the highest polarizatian. However, the quasar 3C 186 at distance .984 almost equals this maximum, indicating that here, too, the onset of the secondary explosions is quite recent, and there is still another quasar in this group that has a polarization above average and is located as far out as 1.272. This evidence suggests that for the quasar population as a whole the secondary explosions are a continuing phenomenon throughout the entire range beyond quasar distance .800.

Such a conclusion is completely in accord with the theory, inasmuch as the growth process of the galaxies results in a continuous distribution of stellar ages from the oldest downward. As soon as the oldest of the constituent stars of a galaxy or a galactic fragment (aside from a few survivors of previous explosive events) arrives at the destructive limit a regular succession of explosions follows. We may also corroborate this conclusion observationally by examining the relation between the quasar distance and the magnitude of the radio flux. We have already found that the average age of the quasars increases with distance. If the explosions persist throughout the range



of distances of the Class II quasars then there should be a gradual build-up of energy, and the average output of radiation from these objects should increase with distance rather than remaining constant in the manner of the Class I quasars. Fig. 13 shows that such an increase actually takes place in the radio flux from the 3C quasars listed in the Burbidge Table 5.1. There is a range of variation at each distance, as would be expected, but the minimum R.F. more than doubles between .800 and 2.000, and the maximum value increases in an almost parallel line.

With these findings as to the nature of the developments during the life period of the Class II quasars, we have now completed the task of tracing the progress of the quasars from the time they are ejected from the galaxy of origin to the time that they acquire unit speed in the two inactive dimensions and disappear into the region of motion in time. In order to place the quasar in its proper perspective, however, it should be emphasized that the existence of this object is not an isolated phenomenon-something that may happen under some special canditions-it is a segment of the great cycle of physical existence, something that eventually happens, in one way or another, to all matter. The quasar state is an integral part of the physical cycle; it is the connecting link between the old in the material sector of the universe and the new in the inverse, or cosmic, sector.

CHAPTER XI

The Pre-Quasar Situation

Although the preceding chapter completes the discussion of the quasar phenomenon per se, so far as we are justified in carrying it in a general work of this kind, there are some additional subjects that are so closely related to the quasars that they should also be given some attention before concluding the presentation. These are items that are involved in the situation which exists while the forces that will ultimately produce the quasars, in the normal course of events, are in the process of building up.

As emphasized throughout the discussion in the previous pages, the initial event in the explosive process that produces the quasars is the disintegration of one or more individual stars that reach the destructive age limit. In what may be called the normal pattern, the oldest stars are located in the interiors of the largest galaxies (which, according to the theory, are the oldest) and as these stars successively arrive at the limit and explode they build up tremendous forces that ultimately break through the overlying material and throw off fragments of the galaxy, including the quasars, which are ejected at speeds greater than that of light. Subsequently, additional stars within the quasar also reach the age limit and explode, altering the properties of the quasars.

This fact that the energy of each of the major explosive events comes from an accumulation of relatively small (compared to the final energy release) energy increments contributed by explosions of individual stars has some important consequences even before the ejection of the quasar. We can deduce, for instance, that the accumulation of enough energy to cause this ejection extends over a considerable period of time, and it follows that we should be able to detect objects in which the build-up of energy is under way. Such objects are, of course, galaxies, and we should be able to find certain types of galaxies in which we can observe indications that large amounts of energy are being generated by processes that involve ultra high speeds.

One of the first possibilities that must be considered is that the N-type galaxies may not have the significance that was attributed to them in Chapter VIII, and are instead galaxies that are building up energy for the quasar ejection. The available evidence is not adequate to resolve this question conclusively, but at the moment the odds seem to be rather strongly in favor of the hypothesis that these are the galaxies in which the quasars have actually been ejected behind the galaxies of origin, but are moving only in time and not spatially. The points in favor of this explanation were summarized in Chapter VIII, and as matters now stand they are persuasive enough to give the occlusion hypothesis the preference.

Furthermore, there are not enough of the N-type galaxies. The pre-ejection stage in which the explosive forces are gradually building up must be a long one, and since all, or nearly all, large galaxies pass through this stage, galaxies that are in this condition should be very common, much more common than the N-type objects. Another item that has a bearing on this question is that many galaxies which we have good reason to believe are already in one stage or another of the explosion process do not exhibit the N-type characteristics. The presence of jets of luminous material, for instance, is *prima facie* evidence of the existence of internal forces of the kind that can cause ejection of quasars when they reach a high enough level of magnitude. But the galaxies with jets, of which M 87 is the most conspicuous example, are not N-type galaxies; they are, for the most part, giant elliptical galaxies of what may be called a standard type. The significant feature that they do have, the feature that links them with the explosive phenomena of the kind that produces the quasars, is that they emit substantial amounts of radiation at radio frequencies; that is, they are “radio galaxies.”

The conclusion that this points to is that the galaxies which are in the stage of building up the internal pressure that will ultimately result in ejection of quasars are simply giant old galaxies that reveal their turbulent internal condition only by their radio frequency radiation, except in those cases where there are leakages that show up as jets or similar phenomena. This is a conclusion that fits easily and naturally into the general structure of theory. Even the most elementary consideration of the theoretical situation indicates that the explosions must normally take place in the interiors of the oldest and largest galaxies. (This was explicitly stated in the 1959 publication.) The observations indicate that the strongest radio galaxies are giants-elliptical or large spiral types-the very ones that, on the basis of the theory, should be building up the forces necessary to produce the quasars.

Although current astronomical thougbt has not yet reached the point of recognizing that there is a destructive event at the end of the life period of each galaxy, or even recognizing that there is a definite correlation between size and age, it is beginning to be realized that some kind of a limit exists, and that this fact requires an explanation. Fred Hoyle poses the question specifically: “Galaxies apparently exist up ta a certain limit and not beyond that. Why?”48 J. G. Bolton goes a step farther and identifies the limit with radio emission. He points out that

The radio galaxies are at the upper end of the luminosity function for all galaxies which suggests that radio emission may be associated with some stability limit.49

There is also a growing realization that some explanation will have to be found for the observed fact that the masses of the giant elliptical galaxies are abnormally high in proportion to their luminosity. According to a recent news item, “They are about 70 times more massive than they should be if they are made up entirely of stars like the sun.”50 Conventional astronomical theory provides no mechanism whereby such an alteration of the mass-luminosity relation can be accomplished. It is recognized that most of the discrepancy would be accounted for “if one assumes that elliptical galaxies are extraordinarily rich in dim white dwarf stars,” but there is no visible justification for any such assumption. Here again, therefore, the theorists are resorting to the ancient device of a “demon.” The investigators quoted in the news report are postulating the existence of “black holes,” hypothetical concentrations of mass so large that radiation cannot escape from them, and are then making the purely *ad hoc* suggestion that the elliptical galaxies are well supplied with these purely hypothetical “black holes.”

In the context o£ the Reciprocal System there is no mystery at all about the mass situation in the elliptical galaxies, or the existence of a limiting galactic size. These are simply two aspects of the evolutionary pattern of the galaxies. As painted out in the preceding pages, a “star pressure” is building up in the interiors of the older galaxies; that is, an increasing proportion of the constituent stars are being accelerated to ultra high speeds by the energy released in the explosion of stars that reach the destructive age limit. The cores of these galaxies are thus in the same condition as the white dwarf stars and the quasars; their density is abnormally high because the introduction of the time displacement of the ultra high speeds reduces the equivalent space occupied by the central portion of the galaxy. In brief, we may say that the reason for the abnormal relation between mass and luminosity in the giant ellipticals is that these galaxies have white dwarf cores-not white dwarf stars in the core, but white dwarf cores. As a galactic core increases in mass and energy, with an accompanying increase in the intensity of the radio emission, it ultimately reaches the point where the internal pressure is sufficient to eject portions of the galaxy. The limitation on galactic size is thus an indirect result of the age limit to which matter is subject.

Like the quasar 3C 273, with which it is associated, the galaxy M 87 is of special interest because it is the only member of its class near enough to be accessible to detailed investigation. This object has all of the features that theoretically distinguish a galaxy that has reached the end of the road. It is a giant elliptical, with the greatest mass of any galaxy for which a reasonable estimate can be made; it is an intense radio source, one of the first extragalactic sources identified; and a jet of high velocity material emitting strongly polarized light can be seen originating from the nucleus of the galaxy. These indications of explosive activity are so evident that they were recognized just as soon as the theoretical limits to the life of the galaxies were discovered, long before the existence of galactic explosions was recognized by the astronomers. The 1959 publication contained this statement: "It would be in order to identify this galaxy (M 87) , at least tentatively, as one which is now undergoing a cosmic explosion."

Another point of interest in connection with M 87 is that there have evidently been at least two ejections prior to the action that is now taking place. According to Arp, the average recession speeds of the galaxies in different parts of the region around M 87 range from about 400 km/sec more than the speed of M 87 to about 400 km/sec less.38 Any quasar or radio galaxy within about .0015 of the .0031 recession of M 87 is therefore a member of the cluster of galaxies (the Virgo cluster) centered around M 87 and is a possible explosion product. Arp's association 134, listed in Table II, includes the quasar 3C 273 and the radio galaxy 3C 274, both of which are within the limits specified. In the same vicinity there is another quasar PKS 1217+02, with a redshift of .240, equivalent to a recession shift of .0045, and emitting only about one-thirtieth as much energy as 3C 273. There are also several radia galaxies in the same neighborhood with redshifts that qualify them as possible partners of the second quasar. We may therefore conclude that PKS 1217+02 and one of the nearby radio galaxies, perhaps 3C 270; with redshift .0037, were ejected in an explosion subsequent to the 3C 273 event.

The conclusion that 3C 273 was produced earlier than PKS 1217+02 follows from the status of the latter as a member of a group of relatively young objects, the Class I quasars, whereas 3C 273 is a Class II quasar and, as brought out earlier, is probably as old as the normal members of its class, which do not appear short of a quasar distance of .800. In this connection, it will be of interest to see what can be done, by using the information developed in the preceding chapters together with what we have here deduced regarding the M 87 situation, in the way of a more specific evaluation of the time scale of the various stages of the existence of the quasars.

On the basis of the currently favored "big bang" theory of the origin of the galactic recession, a galaxy which is now receding from us at or near the speed of light has been moving at this speed ever since the "bang" occurred. Our findings indicate, however, that the "big bang" is purely mythical, and that the galaxy in question did not travel the full distance out to its present location but originated at some intervening point and moved outward from there, gradually accelerating by reason of the attenuation of the oppositely directed gravitational motion with increasing distance. Each point in the line of travel corresponds to a specific velocity of recession, and in order to compute the time required to move from one location ta a more distant one we must integrate between these limits. If we take the value of the Hubble constant as 100 km/sec per million parsecs, we find that the maximum life span of a Class II quasar, the time required to move from a quasar distance of .800, where the Class II quasars first make their appearance, to 2.000, the limit beyond which they disappear from view, is about 9 billion years.

Examination of the information thus far accumulated indicates that it is necessary to go out to a quasar distance of about .450 before there are enough Class I quasars to account for the number of Class II quasars that appear around distance .800. We may therefore take the time required to move from .450 to .800, about 6 billion years, as an approximation of the time that elapses between the original ejection of the quasar and the beginning of the Class II activity. This puts the maximum life of a quasar somewhere in the neighborhood of 15 billion years.

In the light of current thought, which regards the quasars as short-lived objects-"brilliant but ephemeral," as Greenstein termed them in the statement quoted in Chapter I-this canclusion may seem altogether fantastic. It should be realized, however, that the quasar as it emerges from the theoretical development in this work is a very different object from the quasar as currently visualized. To the astronomer, the quasar is an object of uncertain origin and nature, with a number of unusual properties, some of which, such as the large output of radiant energy, seem unlikely to be capable of continuing over any greatly extended period of time. On this basis the quasar must be short-lived. In the context of the Reciprocal System, on the other hand, the quasar is a galactic fragment-a small galaxy -which displays these unusual characteristics only during certain periods of its existence. Unless it attains the Class II status, which most quasars apparently do not, the active stage is relatively short, and throughout the remainder of its long journey out to the 2.00 distance limit it is rather obscure, distinguished only by its large redshift and some other evidence of ultra high speed.

Objects that answer the description of quasars in their radio quiet stage are well known, but not well understood, and still somewhat controversial. The Burbidges make this comment:

Same starlike objects were found that are similar in all their optical properties to the quasi-stellar radio sources but do not emit any detectable radio energy. They have variously been described as quasi-stellar objects, blue stellar objects, quasi-stellar galaxies, and interlopers.51

Sandage has made a special study of these radio-quiet quasars and has concluded that they constitute "a major new constituent of the universe." His results indicate that these objects may be 500 times more numerous than the active quasars.52 This would mean that each quasar spends approximately two-tenths of one percent of its total life span, or about 30 million years, in the active Class I stage. However, most of those who have commented on the Sandage estimate suggest that it is too high, and if it is reduced to some extent the indicated active life of the quasar will be increased accordingly. An active life of 100 or 200 million years would seem more in line with the general scale of quasar ages. The present tendency is to talk in terms of around a million years,53 but this is predicated on energy calculations based on the assumption of a three-dimensional distribution of the quasar radiation, and it is not realistic in the light of our new findings.

In any event, the characterization of these Class I quasars in their quiet stage as a “major constituent of the universe” lends additional emphasis to the point brought out at the end of Chapter X: the fact that the quasar is not a freak or an abnormality whose existence has to be explained by some unusual combination of circumstances. Like any other “major constituent” it has a definite and significant place in the main stream of physical activity, the kind of a place that it occupies in the theoretical universe of the Reciprocal System.

Thus far we have been considering the situation which may be considered normal, where the oldest stars are in the interiors of the oldest galaxies, but inasmuch as the basic units, from the standpoint of the aging process, are the individual stars, we can expect to find frequent deviations from the normal pattern. A galaxy may, for example, capture a number of relatively old stars quite early in its life, or it may even pick up some old star clusters or a small galaxy of a fairly advanced age, a remnant of an exploding galaxy, for example. These older stars will reach the destructive age limit and explode before the galaxy arrives at the stage where such explosions are normal events. If the premature activity of this kind is not extensive, the energy that is released is absorbed in the normal motions of the galaxy. But where a considerable number of stars-those in a captured cluster, perhaps-reach the age limit in advance of the normal time, some significant results may follow.

For instance, if large scale activity of this kind begins when the galaxy is in an earlier stage where it is smaller and less compact than the giant ellipticals, the internal action will not be as much obscured by the overlying material, and we may observe some effects of the ultra high speeds in addition to the radiation at radio frequencies. There is an observed class of spiral galaxies that exhibits just the kind of behavior that is to be expected from a galaxy in this condition: one that is experiencing what we may call a premature large-scale series of explosions. These Seyfert galaxies, as they are called because they were first described by C. K. Seyfert, are smaller than the giant ellipticals, and by reason of the spiral structure, in which much of the galactic mass is spread out in the form of a disk, their central regions are relatively exposed, rather than being buried under the outlying portions of the galaxy, as is true in the big ellipticals. Whatever action is going on in the Seyfert galaxies is thus more accessible to observation.

The observable evidence of this action is fully in agreement with the theoretical conclusions. Aside from the great difference in red shifts, the nuclei of these galaxies are remarkably similar to the quasars. As expressed by R. J. Weymann, “Except for an apparent difference in luminosity, Seyfert galaxies and quasars may represent essentially similar phenomena.” The findings discussed in Chapter VIII indicate that the actual luminosity difference is not as great as has been thought, but some difference in luminosity is understandable, as the events taking place in the Seyfert galaxies are phenomena of the pre-ejection stage and are much less violent than those which occur during and after ejection. Weymann points out that the spectral characteristics of the light from the nuclei of these galaxies are quite different from those of the light coming from the outlying regions.

Ordinary stars (such as our sun) emit more yellow light than blue light. This is also the case if one observes a Seyfert galaxy through an aperture that admits most of the light from the galaxy. As the aperture is reduced to accept light only from the central regions, however, the ultraviolet and blue part of the spectrum begins to predominate.26

This is another piece of information that fits neatly into the general theoretical picture. We have deduced from theory that the predominantly yellow light (positive U-B) that we receive from ordinary galaxies is characteristic of matter moving with speeds less than that of light, whereas the predominantly ultraviolet light (negative U-B) is characteristic of matter moving with ultra high speeds. Now we observe an otherwise normal galaxy with a nucleus in which there is some unusual activity. From theoretical considerations we identify this activity as being due to a series of stellar explosions that are accelerating some aggregates of matter to speeds in excess of the speed of light, and we find that the light from this galaxy displays exactly the characteristics that the theory requires.

A very significant point here is that the violent motion in the cores of the Seyfert galaxies that is predicted by the theory has actually been detected observationally. Weymann reports that the emission spectra of the Seyfert galaxies "indicate that the gases in them are in a high state of excitation and are traveling at high speed in clouds or filaments. Outbursts probably occur from time to time, producing new high-velocity material." This, of course, is a good description of the state of affairs that the theory says should exist, not only in the Seyfert galaxies, but in the cores of the giant ellipticals as well. To the astronomers the whole situation is a "puzzle" because, unlike the Reciprocal System, conventional theory provides no means, other than gravitation, of confining high speed material within a galaxy, and gravitational forces are hopelessly inadequate in this case. Weymann summarizes the problem in this manner:

If we accept the fact that the gas inside the tiny core of a Seyfert galaxy is moving at the high apparent velocity indicated by the spectra, and if we assume that the gas is not held within the core by gravitation, we must explain how it is replaced or conclude that the violent activity observed in the core is a rare transient event caused by some explosive outbursts.

But the latter possibility, he concedes, is inadmissible, because the Seyfert galaxies "cannot be considered particularly rare." Hence this piece of observational evidence that is such a significant and valuable item of confirmation of the theory described in this work, not only the theory of the Seyfert galaxies, but the whole theory of the galactic explosion phenomena, including the quasars, is nothing but another enigma to conventional theory

. The same factor that makes the internal activity of the Seyfert galaxies more accessible to observation than that of the giant ellipticals, the thinner layer of overlying material, also limits the kind of products that can result from such activity. In these smaller galaxies it is not possible to build up the great concentration of energy that is necessary in order to produce a quasar, and the ejections of material therefore take a less energetic form. The most common result is nothing more than a jet or an outflow of matter in a less concentrated pattern, but in certain instances it can be expected that a fragment of the galaxy will be ejected, without the ultra high speed of the quasar. Such a fragment will be similar to the radio galaxies ejected in conjunction with the quasars, but may have some points of difference on account of the lower energy environment in which it was formed.

Similar less violent ejections may also take place from the elliptical galaxies under appropriate circumstances, and a further study of the M 87 jet phenomenon may throw some light on this matter. It has been noted54 that the galaxy M 84 (radio source 3C 272.1) is aligned with this jet in such a manner as to suggest that the galaxy may have been formed from material ejected in the jet, or in a more active phase of the same explosive event that preceded the jet phase. A small counterjet has been found by Arp on the opposite side of the galaxy, and it seems quite possible that these jets constitute one stage of a long-continued emission in which the greater part of the ejected material comes out with speeds less than that of light. It no doubt takes an appreciable time to close off the opening left by the ejection of a section of the galaxy, and during this interval there must be some leakage of energetic material from the galactic interior. The present activity of M 87 could well be an after-effect of the most recent quasar ejection: a secondary process that was strong enough immediately after the primary ejection to throw off a rather large fragment (M 84) but is now down to a lower level of activity, and will eventually terminate as M 87 resumes its full spheroidal shape.

Ultimately, after a number of ejections have occurred, an exploding galaxy such as M 87 will have lost so much of its substance that it will be unable to resume its normal shape and once more confine the exploding material to the interior of the structure. From this point on the products of the stellar explosions will be expelled at more moderate speeds in the form of clouds of dust and gas, and the pressures necessary for the ejection of fragments of the galaxy will not be generated. The galaxy M 82, the first in which definite evidence of an explosion was recognized, seems to be in this stage. Photographs of the galaxy taken with the 200 inch telescope and reproduced in the article by A. R. Sandage previously cited2 show immense clouds of material moving outward, and the galactic structure appears badly distorted.

Just how large M 82 may have been in its prime, before it began ejecting mass, cannot be determined from the information now available, but at present it is in the range of a rather small spiral. Sooner or later its remnants, like those of all other over-age galaxies, will be swallowed up by a larger neighbor. The eventual fate of M 82 is clearly foreshadowed by the comment in the Sandage article that the evidence of explosive events in this galaxy was discovered in a survey of "a group of visible galaxies centered on the giant spiral galaxy M 81."

It is evident from the many items covered in the preceding discussion that the term "radio galaxy" covers a wide diversity of objects. Violent events that cause atomic readjustments result in radio emission whenever they occur, and any galaxy in which large scale action of this kind is taking place qualifies as a radio galaxy. This classification thus includes (1) giant old galaxies that are building up internal forces which will ultimately result in explosions and ejection of quasars, (2) smaller spiral galaxies in which less violent explosive events are occurring, (3) galaxies that have already lost substantial portions of their mass by reason of explosive ejections and are undergoing internal readjustments, (4) fragments ejected in conjunction with quasars, and (5) fragments ejected in less violent explosions.

To these, the theoretical development indicates that we should add a sixth: galaxies in the process of collision. The collision hypothesis was quite popular as an explanation of the radio emission in the early days of radio astronomy, one of the principal reasons being that Cygnus A, the most powerful extragalactic radio source known at the time, appeared very much like two colliding objects in the photographs taken with the 200 inch telescope. This hypothesis is now out of favor, mainly because conventional theory indicates that two galaxies should pass through each other with little interaction. The assertion of the Reciprocal System of physical theory tllat the stars of a galaxy occupy equilibrium positions and thus participate in a structure similar to that of a liquid puts a much different light on this situation. On this basis, one galaxy cannot pass through another. The collision is equivalent to an inelastic impact of liquid aggregates, and the kinetic energy of motion of the incoming galaxy must be absorbed by the constituent stars of the two interacting units. Some of these stars will be sufliciently excited to produce radio frequency radiation.

The theoretical development also reveals that galactic collisions must be relatively common, as the capture of smaller galaxies by larger ones plays a significant part in the process af growth that ultimately produces the giant elliptical galaxies from which the quasars originate. Galactic collisions account for some of the "peculiar" galaxies that the astronomers now recognize as an important component of the galactic population. Those galaxies that have been distorted and partially disintegrated by explosions, such as M 82, constitute another component of this category, and it is quite likely that there are a number of other varieties of "peculiarity" that will come to light as astronomical investigation continues.

In addition to the confirmation supplied by the observations of the violent activity in the cores of tbe Seyfert galaxies, there is a great deal of other evidence supporting the theoretical conclusion that the energy for all of the explosive events in the galaxies is derived from a multiplicity of individual sources within the galactic aggregate. The highly variable nature of the radio emission from many of the sources is a strong indication of separate events, particularly since some of these variations are rapid enough to justify being called "bursts." In other cases the emission has been found to originate at many different locations within the galaxy. G. R. Burbidge reports, for example, that a number of small radio sources exist in the nucleus of M 87.55 These are not individual stars, since the total number of stars contributing to the emission at any one time must be very large, but the observations do show that we are dealing with multiple sources rather than a single large source.

Although the stellar explosions which we now recognize as the ultimate energy sources for all of the explosive events that have been discussed in the past few chapters are quite infrequent in the disk of our galaxy, we can expect them to occur more often in the core, where the older stars are concentrated. Weymann points out in his article on the Seyfert galaxies that the phenomena which distinguish these objects may very well exist on a reduced scale in other galaxies, and he reports that "radia observations indicate that something quite unusual is going on in the center of our own galaxy," also that small sources of intense radio emission have been found in the nuclei of a number of ordinary spiral galaxies. This is just what we would expect on theoretical grounds.

Here is the last link in the complete pre-quasar sequence. In yaung galaxies and in the outer portions of the older galaxies explosions of stars that reach the age limit occur as individual events, and their energy is dissipated among their surroundings. In spiral galaxies of moderate size, such as our own, the explosions in the galactic core, where the average age of the stars is the greatest, become frequent enough to produce a small permanent source af intense radio emission. As galactic age and size increase, the explosions become still more frequent, the active region becomes larger, and the internal pressure due to the ultra high speed of the explosion products rises.

If the pressure rise is relatively rapid, so that the ejection pressure is approached, or actually reached, while the galaxy is still in the spiral stage, the Seyfert phenomena make their appearance; otherwise the galaxy assumes the spheroidal shape eventually, and the ultra high speed activity is hidden (except for the radio emission) beneath the heavy layer of overlying material. This increased resistance to penetration by the explosion products permits building up higher pressures, until finally the outer layers give way and ejection of one or more fragments takes place. If the pressure build-up continues to the maximum before the ejection one of the ejected products is a quasar

Here, then, is the pattern of the pre-quasar events, from the individual stellar explosion to the birth of the quasar, as we determine it from the same theory that was applied to the investigation of the quasars themselves. All along the line, we find every item falling into place easily and naturally in the precise manner required by the applicable theoretical considerations.

CHAPTER XII

Supernovae and Pulsars

The principal feature that makes M 87 a particularly attractive subject for investigation, the fact that it is close enough to enable recognition of details that are lost at the greater distances, is even more pronounced in the case of our own Milky Way galaxy. Of course, our galaxy is not a giant elliptical, or even a Seyfert spiral, but it is after all, a reasonably big and reasonably old galaxy. Such a galaxy clearly must have accumulated some of the relatively old stars that are scattered around so profusely by the galactic explosions. As time goes on, one after another of these old stars will reach the age limit and explode, even while the galaxy as a whole is well below the normal limiting age. We have already found that a star which reaches the lower explosive limit (in efEect a temperature limit) explodes and produces a phenomenon that we have identified as a supernova. If we call this a Type A stellar explosion, then we can express the new conclusion that we have reached through a consideration of the probability of the presence of some very old stars in the younger galaxies by stating that in these galaxies there must also exist Type B stellar explosions that have some quite different characteristics because they occur at the age limit rather than at the temperature limit.

In the terminology of the astronomers, any full-scale explosion of a star is a supernova, and the foregoing statement therefore asserts that there are two distinct types of supernovae. The existence of two different types of these events has already been recognized observationally, and this fact is sufficient in itself to demonstrate the validity of the theoretical conclusion. We have deduced theoretically that there are two different types of stellar explosions; the observations confirm the deduction by disclosing that supernovae exist in two different types.

So far in this work we have used the term supernova only with reference to the Type A explosions, those that occur when stars reach the lower explosive limit, and whatever has been said as to the nature of these events and their products applies specifically to Type A. Throughout the discussion in the final chapters of this volume, however, it has been emphasized that the basic energy sources underlying the quasars and all associated phenomena are the explosions of stars that reach the upper destructive limit: the Type B explosions. At this point we need to recognize that the explosions of this second type are similar enough to those of Type A in their general nature and in their products that they also appear to observation as supernovae, and the available observational data therefore include some information on Type B events. Here, then, we have an opportunity to extend our inquiry to an examination of this important class of explosions in an evironment where they can be observed individually.

Unfortunately, these observations of the individual events can only be made under some rather severe handicaps. No observable supernova has occurred in our galaxy for nearly 400 years, and information about the active stage of these explosions can be obtained only from extragalactic observation, aside from such deductions as can be made from imprecise eyewitness accounts by observers of the supernovae of 1604 and earlier. Our most significant information comes from examination of the characteristics of certain astronomical objects, a few of which are known to be remnants of old supernovae and others that are similar enough to justify including them in the same category. Even at best, however, the hard evidence is scarce, and it is not surprising that there is considerable difference of opinion among the astronomers as to classification and other issues. For this reason our deductions from theory conflict with some current thought, but there is a rather general correspondence between the theoretical products of our Type A explosions and the astronomers‘ Type I supernovae; likewise between the theoretical products of our Type B explosions and the astronomers‘ Type II supernovae. For purposes of the subsequent discussion we will therefore equate A and B with I and II respectively.

The Type A explosion is a single event which theoretically originates from a hot, massive star at the upper end of the main sequence, a member of a group of practically identical objects. All Type I supernovae are therefore very much alike. As expressed by R. Minkowski, one of the leading investigators of these events, “The Type I supernovae form a very homogeneous group.”56 Current astronomical opinion regards the Type II supernovae as the ones that originate from the hot, massive stars, but this opinion is based on theory, not on observation, and our theory simply arrives at a different conclusion. The magnitude of the Type I supernova at the peak is relatively high, and the decay rate in the early stages is relatively low, but the overall life as compared to that of a Type II supernova is nevertheless short, for reasons which we will discuss later. The Type I supernovae are widely distributed among the various types of galaxies, as they occur, or at least may occur, fairly early in the life of the stars that are involved. This is another point of conflict with current thought, or more accurately, it is another aspect of the same conflict, as the current view of the supernova distribution is based on the identification of the hot, massive stars with Type II rather than Type I. This leads to confusion, as can be seen when Minkowski says that the Type II supernovae are the ones that occur in the Population I stars of the spiral arms, while at the same time he identifies all of the historical supernovae in the salar neighborhood (in a spiral arm of our galaxy) , other than the Crab Nebula, as belonging to Type I.57 In the context of the Reciprocal System of theory, the hot, massive Population I stars are highly evolved first generation objects (stars which have not yet passed through the supernova stage) . The stars that produce Type II supernovae are either much older unevolved first generation stars or members of later generations.

The Type I supernovae do not actually enter into the subject matter of the present discussion of the quasar class of phenomena, except through their association with the Type II objects, and we will therefore turn our attention to the latter, commenting further on the characteristics of Type I only where a comparison with these objects is of assistance in clarifying the Type II picture. Aside from the previously mentioned fact that it occurs much later in the life span of the star-at the very end-the most distinctive feature of the Type B explosion is that it generates enough energy to give the explosion products the speed that is required in order to carry them beyond the neutral point and into the region of motion in threedimensional time.

The total mass participating in this explosion may be either greater or less than that of the kind of a star that becomes a Type I supernova, as the Type II event may involve anything from a single dwarf star to a whole n-generation stellar system of six or eight units. But the Type B explosion converts a much larger percentage of this mass into energy, and the ratio of energy to unconverted mass is therefore considerably higher, producing a much greater average particle speed, and thereby increasing the proportion of the total mass going into the high speed explosion product. The Type B explosion also has the character of radioactivity, in that the initial outburst does not complete the action, but is succeeded by a period of gradually decreasing activity extending over a long period of time. The optical emission from a supernova comes mainly from the slow speed component of the explosion products, the material expanding outward in space, and since the amount of this material is much smaller in the Type II events, the optical magnitude of the Type II supernova at the peak is considerably less than that of the average Type I event, despite the greater total energy release in Type II. A recent investigation arrived at average magnitudes of -18.6 for Type I and -16.5 for Type II.58 The emission from Type II also drops off more rapidly at first than that from Type I, and the light curves of the two types of explosions are thus quite different. This is one of the major criteria by which the observational distinction between the two types is drawn. For example, Minkowski remarks in one case that “The supernova was visible for more than 1 year. This excludes Type II.”59

In view of the limited optical activity and the relatively small mass of the remnants, there has been some question as to what happens to the energy of these Type II events. Poveda and Voltjer, for instance, comment that they find it difficult to reconcile current ideas as to the energy release in the Type II supernovae with the present state of the remnants.60 This question is answered by our finding that the great bulk of the energy that is generated goes into the ultra high speed explosion products.

The radio emission is more representative of the true energy situation. Here we have to depend on observations of the remnants of old supernovae, but the results of the radio measurements on these objects are definite and unequivocal. For example, there is a nebulosity in the constellation Cygnus, known as the Cygnus Loop, which is generally conceded to be a remnant of a Type II supernova, and is estimated to be about 60,000 years old. After all of this very long time has elapsed, we are still receiving almost twice as much radiation at 400 MHz (in the radio range) from this remnant as from the remnants of all three of the historical (1006, 1572, 1604) type I supernovae combined.57

There are a number of other remnants with radio emission that is far above anything that can be correlated with Type I, including Cassiopeia A, the most intense radio source known; IC 443, which is similar to the Cygnus Loop and almost as old, and three remnants in the Large Magellanic Cloud, the strongest of which is reported to have "about 200 times the emitted radio power of the Cygnus Loop."57 Likewise there are remnants whose radio emission is within the range of the Type I products, but whose physical condition indicates an age far beyond the Type I limit. These must also be assigned to Type II. In general, it seems safe to say that unless there is some evidence of comparatively recent origin, aIl remnants with measurable radio emission can be identified with Type II supernovae, even though Type I events may be more frequent in our gaIaxy.

This conclusion enables us to classify the Crab Nebula definitely as a Type II product. The radio flux from this remnant of a supernova observed in 1054 A.D. is about 50 times that of the remnant of the Type I supernova that appeared in 1006 and is therefore of practically the same age.57 The Crab Nebula was originally assigned to Type I by the astronomers, mainly on the basis of differences between it and Cassiopeia A, which was regarded as the prototype of the Type II remnant, but more recently it has been recognized that the differences between this nebula and the Type I remnants are much more pronounced. Minkowski (1968) concludes that "an unbiased assessment of the evidence leads to the conclusion that the Crab Nebula is not a remnant of a supernova of Type I."57

The greater and longer-lasting radio emission of the Type II supernovae is, of course, consistent with the theoretical results of the greater total energy and the continuing character of the Type II events. Another observational confirmation of the theoretical explanation of the long time scale of Type II comes from evidence of further explosive events subsequent to the original outburst of the supernova. A current explanation of the peculiar features of Cassiopeia A attributes them to the presence of two distinct shells of expanding material. The Crab Nebula is likewise made up of two dissimilar components. Examination of the spectra of extragalactic supernovae also lends considerable support to the "double shell" hypothesis. "The presence of multiple absorption lines in the spectra of many supernovae of Type II suggests that more than one shell has been ejected." (Minkowski) 57

It thus appears altogether possible that the A.D. 1054 supernova and the latest outburst of Cassiopeia A may have been preceded by other major explosive events in the same stars. This suggestion becomes all the more plausible when it is realized that many of the “stars” involved in Type II supernovae are actually star systems double or multiple stars. Both, or all, of the stars in such a system have the same chronological age, but variations in the conditions of existence can very well introduce some differences in the evolutionary age, and hence there may be a substantial interval between the explosions of the components of a multiple star.

This possibility of multiple explosions would also explain what has been a puzzling feature of Cassiopeia A. “Expansion with high velocity clearly indicates that the nebulosity is the remnant of a supernova of moderate age, but no outburst in its position has been recorded.”57 Even a small supernova would have been a target of intense interest at the time calculated for this event, about 1700 A.D., and the idea that an event powerful enough to produce the strongest radio source in the heavens could have passed unnoticed seems preposterous. But if there was already a strong source of optical radiation at this location, one that had originated from previous outbursts, and the supernova of 1700 A.D. did not increase the optical radiation by any striking amount, there is a good possibility that it might have escaped detection. A Type I supernova could hardly have been missed, even under these conditions, but in view of the much lower optical emission from Type II and the faster decay, this explanation is at least plausible. The increase in radio emission would have been immense, but it meant nothing at that time.

In addition to the main outburst or outbursts which constitute the principal feature of the Type II supernova, there is a long-continued supplementary generation of energy as the explosion gradually spreads through additional portions of the affected mass. This continuing action is manifested by the persistence of the radio emission, and by the evidence of energetic events within the remnants. For instance, “the optical remnant of Cassiopeia A is undergoing rapid changes,”61 while the Crab Nebula, another remnant, contains “some formations which are highly variable in appearance and brightness and which move quite rapidly.”62 Calculations alsa indicate that an input of energy into this nebula “of the order 1038 erg/sec” is required to sustain the observed emission.57 The current suggestion is that this energy is injected into the nebula from the central star, but the ultra high speed product emits only a relatively small amount of energy, and therefore cannot be the source of the continuing supply. The supplementary energy has to come from radioactivity within the material ejected in the primary outburst. It is the existence of this secondary energy generation in the Type II supernovae, but not in Type I, that accounts for the great difference between the maximum 165 period of observable radio emission in Type I remnants, perhaps 3000 years, and that in Type II remnants, which we can estimate at more than 100,000 years. This is somewhat similar to the difEerence that we noted between the Class II quasars, which have secondary energy generation and therefore maintain their emission for a billion years or more, and the Class I quasars, that have only the energy with which they were ejected from the galaxy of origin, and therefore fade out after a hundred million years or so.

The same factors that are responsible for the differences between the relatively slow speed products of the two types of supernovae-the remnants-also result in some significant differences between the ultra high speed products of the two kinds of events. Here, again, the general nature of the corresponding products is the same. Just as the slower component in each case is a cloud of dust and gas particles moving outward in space, so the high speed component in each case is a cloud of dust and gas particles moving outward in time. But the greater intensity and other special characteristics of the Type B explosions have some effects that make the behavior pattern of the Type B high speed component significantly different from that of its Type A counterpart, the white dwarf star.

It was mentioned previously that the compact cores of some of the larger galaxies are quite similar to the white dwarf stars in their general aspects. In both cases the constituent units, stars in the core and particles in the white dwarf, are moving with ultra high speeds in a confined space, with the result that additional time is being introduced between the units of matter and the properties of the material aggregate are altered accordingly. Such a galactic core is therefore a giant version of the white dwarf star-a white dwarf core, as we called it earlier-differing only in the nature of the fast-moving units. Similarly, we can regard the ultra high speed product of a Type B explosion as a miniature version of the quasar, as here again the essential difference is merely that the constituent units of the quasar are stars whereas those of the Type B explosion product are particles of dust and gas.

As in the case of the quasar, the energy imparted to the particles of the high speed Type B product is sufficient to carry them past the neutral point and into the region of motion in three-dimensional time. Ultimately, therefore, they will disappear from the material region of the universe, but before they can do this, they, like the quasars, must first overcome gravitation. Compared with the quasar situation, however, the gravitational effects on the supernova particles are minuscule, and the visible results are consequently quite different. The quasar is composed mainly of material particles that are individually moving with speeds less than that of light (even though the aggregates of these particles, stars, are moving at ultra high speeds) , together with fast-moving particles that are spatially confined. The visibility limit for this kind of material is a function of the spatial distance, and the quasar therefore remains as a visible object out to its overall limit of 2.00 even though the gravitational effect in the dimension of the explosion speed is eliminated at a quasar distance of 1.00. However, the ultra high speed particles produced by the Type II supernovae are not spatially confined, and their radiation is invisible beyond a distance of 1.00 in the explosion dimension.

As explained in Ghapter VI, there is a gravitational limit for each aggregate of matter within which the gravitational motion exceeds the progression, and beyond which the progression is the greater. For a star similar to the sun this limit is a little over two light years. Outside the limit the gravitational effect continues to decrease with increasing distance in accordance with the inverse square law, until at another limiting distance the entire mass exerts only one unit of force; that is, it exerts the same gravitational force that one unit of mass exerts at one unit of distance. Inasmuch as fractional units do not exist, there is no gravitational effect at all beyond this outer limit, which is about 13,000 light years for a star of one solar mass. The ultra high speed particles produced by the Type II supernova are traveling at unit speed in the explosion dimension, and their maximum period of visibility is therefore approximately 13,000 years.

In the discussion of the spatial speed of the quasar it was pointed out that only that portion of the explosion speed that is applied to overcoming gravitation has any effect on motion in space, and consequently, the faster the quasar travels the less spatial distance it moves. For instance, at the point where gravitation is down to .500, half of the 1.00 explosion speed causes movement in space, and the other half, the net outward speed, does not. The same principle also applies to radiation. At this same .500 distance, half of the radiation from the ultra high speed explosion product is observable in space and the other half is unobservable. But there are no fractional units, and during each unit of time the radiation must be either spatial or non-spatial; it cannot be divided between the two. Hence the reduction in the spatial radiation below the level of one unit of radiation per unit of time takes place in the number of units of timeduring which the radiation appears in space; that is, the radiation is intermittent.

At .500, alternate units are spatial. The natural unit of time has been evaluated in previous publications as .152 x 10-15 seconds. We thus receive radiation for this length of time, after which there is a quiet interval of .152 x 10-15 seconds, then another flash of radiation, and so on. Obviously an alternation at such extremely short intervals cannot be distinguished from continuous emission, but as the high speed explosion product moves outward the ratio of spatially active to spatially inactive units of time decreases, and when the age of this product begins to approach the 13,000 year limit the ratio becomes small enough to make the periodicity evident. Under these conditions the radiation is received as a succession of pulses. For this reason the observed ultra high speed product of the Type II supernova is known as a *pulsar*.

Approximately 60 pulsars have been located since the first of these objects was discovered in 1967, and it appears that this number includes most of those within range of the available facilities. According to Hewish, “it does not seem likely that the number will increase significantly until new radio telescopes of greater collecting area are available.”[34] The distribution and observed properties of these objects have been interpreted as indicating that they are situated within the galaxy and at distances mainly within 2 or 3 Kpc. This is consistent with the theoretical conclusion that they are products of Type II supernovae. Furthermore, two of the pulsars have been definitely identified with supernova remnants, and A. J. R. Prentice has found somewhat less conclusive evidence of correlations with four more. He summarizes his report in these words, “I present evidence that most pulsars may have been formed in Type II supernova explosions and initially possessed extremely high velocities, of order 1000 km s-1.”[63] The theoretical points of similarity between the pulsar and the quasar have also been recognized observationally. P. Morrison asserts that “Quasi-stellar radio sources are analogous to pulsars in every respect save that of scale,”[64] and he suggests that quasars are simply giant pulsars. The situation as we find it theoretically is somewhat more complicated than this, but as a first approximation the statement is correct.

Like their Type I counterparts, the pulsars may accrete material from their surroundings and become visible as white dwarf stars. The conditions are unfavorable for such accretion, however, because of the short lifetime of these objects and the limited amount of slow speed material available for capture, and so far only one such star has been definitely located. This is the star associated with the pulsar in the Crab Nebula, where the environment seems to be quite unusual, perhaps, as suggested previously, because of an earlier explosion at the same location. The relatively low polarization of the radiation from the Crab Nebula pulsar, contrasted with the complete polarization of that from PSR 0833, the next youngest of these objects, is indicative of a significant environmental difference. Inasmuch as the pulsar radiation emanates almost entirely from particles of matter moving at ultra high speeds it is almost completely polarized on emission, and a lower polarization measurement can be taken as evidence of depolarization.

A large amount of effort has been devoted to a search for white dwarfs in the pulsar positions because of the relevance of this information to the theories which picture the pulsars as white dwarfs existing under some special conditions, and “the failure ta detect them optically despite careful searches”34 has weighed heavily against the white dwarf theories. Our findings are that the pulsars may assume the white dwarf status, but in most cases will not, and the lack of success in these searches is not surprising. The most likely prospects for optical detection would seem to be those pulsars in which the polarization is relatively low. PSR 0833, which has been one of the principal targets of the search, is probably one of the least likely to be emitting any significant amount of optical radiation.

From the explanation of the origin of the pulsars given in the foregoing paragraphs it is evident that the pulsation periods must be increasing at a measurable rate. Here, again, the observations confirm the theoretical conclusion. “The periods of all pulsars thus far studied are systematically increasing,”34 says Hewish. Since the decrease starts from the gravitational limit in all cases and follows a fixed mathematical pattern, the period of a pulsar is an indication of its age, and this correlation provides a means whereby we can arrive at some conclusions concerning the time scale of these objects.

The individual pulsar time scales will vary to some extent because they are based on the gravitational limits. and these limits are dependent on the stellar masses involved, but we may establish some values on the basis of the solar mass, as an indication of the general situation. Initially, the exploding star is outside the gravitational limit of its nearest neighbor, and the gravitational restraint on the pulsar is mainly due to the slow-moving remnants of the explosion. This effect decreases rapidly, however, and within a short time the gravitation of the nearest neighbor is the controlling factor. Because of the complexity of this initial situation we are not able to take it as a reference point, but we do know both the age and the period of the Crab Nebula pulsar, NP 0532, which are 900 years and .033 seconds respectively, and we can base our calculations on these figures.

At the gravitational limit the radiation is continuous; that is, radiation is received during 6.6 X 1015 units of time in every second. But in 900 years the pulsar, traveling at the speed of light in the explosion dimension, has moved out to a distance of 900 light years in this dimension (a distance analogous to the “quasar distance” of the earlier discussion) , and by reason of the attenuation of the gravitational force the radiation has been reduced to the point where it is only being received 30 times per second. The ratio of this pulsation period to the initial period is 2.2 X 1014, and the corresponding distance ratio, by reason of the inverse square relation, is the square root of this value, or 1.5 X 107. Dividing 900 years by 1.5 X 107 we obtain 6 X 10-5 light years as the effective gravitational limit. This means that at this distance, about 500 times the stellar diameter, the sum of the gravitational effects of the neighboring star and the remnants of the supernova is equal ta the space-time progression, and the radiation is still continuous. Beyond this point there is a pulsation with an increasing period.

Looking now in the other direction from the reference pulsar, toward objects of greater age, PSR 0833, the second youngest of the pulsars now known, has a period of .089 seconds, which corresponds to an age of 1470 years. This pulsar is therefore nearly 600 years older than the one in the Crab Nebula. The longest period thus far discovered is 3.475 seconds, which indicates an age of 900 years. Some still longer periods are possible before the ultimate limit of about 13,000 years is reached, but these long period pulsars will probably be faint and difficult to detect. An interesting subject for investigation is the pulsar that should theoretically exist in the supernova remnant Cassiopeia A. If this supernova occurred only 300 years ago, as the motions of the remnants indicate, these remnants should contain a pulsar with a period only one-ninth that of the pulsar in the Crab Nebula. This is 270 pulses per second, which will no doubt be difficult to detect, but not necessarily impossible.

A study of the indicated age distribution of the 50 pulsars listed in the article by Hewish in the 1970 *Annual Review of Astronomy and Astrophysics* discloses a rather unexpected situation. On the basis of the theoretical relation between period and age, these pulsars are distributed through an age range of at least 10,000 years. During 6000 years of this total, the first 4500 and the most recent 1500, only 6 pulsars appeared, an average of one every 1000 years. But in the intervening 4000 years 44 pulsars made their appearance, one in every 100 years. Furthermore, the rate of formation did not build up gradually to a peak and then decrease slowly, as might be expected; it rose quite suddenly, held nearly constant during the 4000 year interval, and then dropped almost as suddenly as it rose.

This seemingly anomalous distribution over the period of time involved may help to provide an explanation of the otherwise excessive number of pulsars. A rate of one per hundred years in a small section of one galaxy is clearly inconsistent with current estimates of the average number of Type II supernovae, which are in the range of one per several hundred years for an entire galaxy. However, we have already noted that a galaxy contains many clusters of stars of approximately the same age, and the large number of pulsars originating during the 4000 year period could be the result of a whole cluster of 40 stars reaching the destructive limit almost simultaneously.

Even on this basis, the indicated production of pulsars seems excessive for a region with a radius of only about 3 Kpc, and it may be advisable to give further consideration to the possibility that the pulsars may actually be located at considerably greater distances than those now accepted. Energy considerations, for example, will be favorable to a substantial increase in the distance scale when the twodimensional nature of the radiation from the pulsars is taken into account. However, it may not be necessary to take up all of the existing discrepancy by a decrease in the pulsar density, as the information now available regarding the relatively low visibility of the Type II supernovae suggests that the estimates of the rate of occurrence of these supernovae in the external galaxies are too low. There may well be many extragalactic equivalents of Cassiopeia A: supernovae that have come and gone unnoticed. But in any event, the number of pulsars now known would seem to be more consistent with a distribution over a substantially greater volume.

Indeed, there would seem to be adequate grounds for suspecting that the observed pulsars are distributed throughout the greater part of the galaxy. On this basis, the strong concentration of these objects toward the galactic plane, which is now unexplained, would be consistent with a fairly uniform distribution of the pulsars among the galactic stars, a result that we would naturally expect from the mixing action due to the motion of the galaxy.

As matters now stand, there are no available observational data of sufficient accuracy to enable making an independent check of the pulsar distribution in volume. A comparison of the estimated valumetric concentration of these objects with the corresponding values for the white dwarfs will, however, serve as a rough check on the figure of 13,000 years which we have established as the approximate life period of a pulsar. At first glance this figure seems extremely low in view of the fact that most stages of stellar existence extend into the billion year range, but when we compare the relative space densities of the two classes of objects we find that the life of the pulsars must necessarily be very short. The number of stars in the nearby regions of the galaxy is estimated at about one per 10 cubic parsecs, and about three percent of these are thought to be white dwarfs. The number of white dwarfs per cubic parsec on this basis is .003. Present estimates of the space density of the pulsars lead to a figure of 5 X 10-8 per cubic parsec.34 If we accept the current opinion that the total number of supernovae is divided about equally between the two types, the life periods of the two ultra high speed explosion products are proportional to their space densities.

Multiplying the 13,000 year life of the pulsar by this density ratio, 6 X 104, we arrive at 8 X 108, or approximately one billion years, as the life period of a white dwarf. This figure is probably somewhat low, as the indications are that the number of white dwarfs is currently underestimated, whereas, as we have noted, the space density of the pulsars is probably overestimated, but at any rate, the calculation shaws that the 13,000 year pulsar life is consistent with a billion year life span for the white dwarf.

There is some divergence between the measured rates of increase of the pulsation periods and the theoretical rates corresponding to the respective periods, but they are probably within the range of deviations that can be expected by reason of internal activity within the pulsars. Internal motion can either add to ar subtract from the normal rate of increase of the period, even to the extent, in some cases, of converting the increase into a decrease for a limited time. “Sudden” changes have been reported from both of the two youngest pulsars, NP 0532 and PSR 0833.

In addition to the internal motions, there may be a rotation of the pulsar as a whole, and the fine structure of the pulses is a reflection of these two factors. The so-called “drifting” or “marching” sub pulses, for example, are quite obviously effects of local motions in the pulsar that are being carried across the line of sight by the pulsar rotation. The presence or absence of accreted slow speed material may also have a significant effect. In PSR 0833, for instance, where the 100 percent polarization indicates little or no accretion, there is also little or no fine structure,34 whereas the other young pulsar, NP 0532 in the Crab Nebula, has both a substantial amount of accreted material and a complex pulse substructure.

Of course, most of the figures that we have used in the foregoing discussion of the pulsars are merely rough approximations-aside from the measured pulsation periods, almost any value quoted may be in error by a factor of 3 or 4-but they fit together closely enough to show that the pulsar theory derived from the concept of a universe of motion produces results that are consistent with what little is known about these objects. To the extent that confirmation is possible under the existing circumstances, therefore, this confirms the assertions of the theory that the pulsars are short-lived, ultra high speed products of Type II supernovae.

"It is ironical," says Antony Hewish, "that astronomy's latest discovery, the pulsars, should have been stumbled on unexpectedly during an investigation of quasars, those starlike radio sources whose origin is still one of the outstanding problems of astrophysics."65 But contrary to the implication in this statement, the discovery of the pulsars does not generate a new problem for physical science. The existence of these objects is simply another aspect of the same problem, and when the correct basic theory is applied to the situation, all aspects of this problem-pulsars, quasars, white dwarfs, galactic explosions, and so on-are cleared up in one operation.

The foregoing pages have accomplished their defined objective by deriving a consistent and comprehensive theory of the pulsars, quasars, and associated phenomena, and confirming its validity by extensive qualitative and quantitative evidence. Once it becomes possible to summon enough scientific courage to discard the now untenable concept of a universe of matter, on which all of the hard-pressed traditional theories are based, and to replace it with the concept of a universe in which the basic entities are units of motion, the existence of quasars is one of the inevitable consequences. It has taken a great many pages ta trace the chain of reasoning all the way from the basic concept to the quasar, but this is only because of the amount of attention that has had to be given to the details. The essential elements of the theoretical development are simple, both logically and mathematically.

But it is appropriate to emphasize that this is not just a theory of the quasars and their associates; it is a general theory of the physical universe, one that is applicable to all physical phenomena, and it applies the same principles and relations to astronomical phenomena, including the quasars and the pulsars, that are utilized in dealing with the properties of matter, the behavior of electricity and magnetism, or any other physical entities or relations. The theory was not constructed for the purpose of explaining the quasars; it was in existence years before the quasars were discovered, and no additions were necessary to bring the quasar phenomena within its scope. All that had to be done was to carry the chain of reasoning a little farther in some areas.

Furthermore, the theory employs none of the far-fetched *ad hoc* assumptions that conventional theories find it necessary to utilize even to get a start toward an explanation of the quasar phenomena-such things as "neutron stars," "black holes," "gravitational collapse," "quarks," and the like: fanciful concepts that have no observational support whatever and are simply drawn out of thin air. Indeed , the new theory makes no assumptions at all, other than the assumptions as to the nature of space and time which constitute the basic postulates of the system. Nor does it draw anything from experience. Quasars, pulsars-even matter and radiation-appear in the theory not because they are known from observation, but because they are necessary consequences of the theory itself. The existence of each of these entities is deduced *from the postulated properties of space and time* without introducing anything from any other source.

Finally, it is worthy of note that the new system of theory achieves a high degree of economy of thought. The same explanations that account for the peculiar characteristics of the white dwarf stars also account for the similar characteristics of the quasars, the Seyfert galaxies, and other objects of this type. The same energy sources that produce the great galactic explosions also account for the energy emission from the radio galaxies, for the Type II supernovae, and for the large energy output from the quasars. The same factor that accounts for the nature of the motion imparted to the quasar by the primary galactic explosion also accounts for the relation of the quasar magnitude to distance, for the absence of blueshifts, and for the polarization, not only of the quasar radiation but also that of the pulsars.

The ability of the new theoretical system to provide a comprehensive and detailed explanation of these quasar phenomena with which conventional theory is completely unable to cope is a graphic illustration of the benefits that can be gained by replacing the present “multitude of different parts and pieces that do not fit together very well” with a solidly based and fully integrated theory from which such phenomena as the galactic explosions, the recession, the pulsars, the quasars, the “elementary particles,” and the other items with which the astronomers and the physicists are now having trouble, emerge as essential features of the main line of theoretical development, rather than having to be forced into the theoretical structure by all sorts of questionable expedients.

By this time it should be clear that the traditional physical theories based on the concept of a universe of matter have reached the end of the road; that a continuation of the heroic efforts that are being made to patch the holes and to bolster the elements of the theoretical structure that are failing under the load is no longer justified. After all, there are limits to what can be built on a false foundation, even with the benefit of all of the *ad hoc* assumptions, principles of impotence, and other ingenious devices that the modern scientist utilizes to evade contradictions and inconsistencies and to reinforce the weak spots in his arguments. As the continuing improvement in observational facilities enables penetrating deeper into the far-out regions of the universe, the never-ending task of revising and reconstructing existing theories to conform to the new knowledge becomes progressively more difficult.

The astronomers, who are dealing with physical phenomena on a gigantic scale, are acutely conscious of the awkward situation in which they are placed by the lack of any basic theoretical structure that is applicable to their new discoveries.

Giving the George Darwin lecture to the Royal Astronomical Society last week Professor Fred Hoyle was convincing about the total inadequacy of conventional physics to account for the behaviour of many of the recently discovered objects in the universe. (News item, Oct. 1968) 66

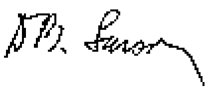
"Total inadequacy" is a harsh term, but it is fully justified under the circumstances, and in calling for a radical revision of the laws of physics to meet present-day needs Hoyle is on solid ground. The physicists cannot deny the need for such changes, as they freely concede that they are encountering equally serious difficulties along the outer boundaries of their own fields, as well as in some of the most basic areas. "What we badly need is a greater synthesis," says Abraham Pais, at the same time admitting that this may "lead us to revise very basic concepts."67 Sir Harrie Massey states the case in these words:

We await a big theoretical advance which will clarify our understanding of the many puzzling features which have been revealed m recent years.68

But this "big theoretical advance" is not something that we must "await." It is already here; all that is now necessary is to recognize it. As the earlier pages of this volume and its predecessors have shown, the essential requirement is a realization that the universe which science is attempting to understand is a universe of motion, not a universe of matter. Once this understanding is achieved, and the logical consequences thereof are followed up in detail, the physicists will have the clarification for which they are asking, and the astronomers will have the revised physical laws that will enable them to bring all of the phenomena of the very large and the very fast within the scope of theoretical understanding in the same manner in which the "mystery" which has heretofore surrounded the quasars and their associates has been swept aside in this work.

DEWEY B. LARSON: THE COLLECTED WORKS

Dewey B. Larson (1898-1990) was an American engineer and the originator of the Reciprocal System of Theory, a comprehensive theoretical framework capable of explaining all physical phenomena from subatomic particles to galactic clusters. In this general physical theory space and time are simply the two reciprocal aspects of the sole constituent of the universe–motion. For more background information on the origin of Larson's discoveries, see Interview with D. B. Larson taped at Salt Lake City in 1984. This site covers the entire scope of Larson's scientific writings, including his exploration of economics and metaphysics.



Physical Science

The Structure of the Physical Universe
The original groundbreaking publication wherein the Reciprocal System of Physical Theory was presented for the first time.

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"A rude and outspoken book."

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New Light on Space and Time
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Explores the implications for physical science of the observed existence of scalar motion.

Quasars and Pulsars
Explains the most violent phenomena in the universe.

Nothing but Motion
The first volume of the revised edition of *The Structure of the Physical Universe,*

The Universe of Motion
The third volume of the revised edition of *The Structure of the Physical Universe,* applying the theory to astronomy.

The Liquid State Papers
A series of privately circulated papers on the liquid state of matter.

The Dewey B. Larson Correspondence
Larson's scientific correspondence, providing many informative sidelights on the development of the theory and the personality of its author.

The Dewey B. Larson Lectures
Transcripts and digitized recordings of Larson's lectures.

The Collected Essays of Dewey B. Larson
Larson's articles in *Reciprocity* and other publications, as well as unpublished essays.

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A scientific excursion into the largely unexplored territory of metaphysics.

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developing the basic principles and relations. Basic Properties of Matter The second volume of the revised edition of *The Structure of the Physical Universe*, applying the theory to the structure and behavior of matter, electricity and magnetism.	economic problem. The Road to Permanent Prosperity A theoretical explanation of the business cycle and the means to overcome it.