The Physical Nature of Space

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Even at best it is a difficult task to convey a clear understanding of a basically new scientific concept. Regardless of how simple the concept itself may be, or how explicitly it may be set forth by its originator, the human mind is so constituted that it refuses to look at the new idea in the simple and direct light in which it is presented, and instead creates wholly unnecessary difficulties by insisting on placing the innovation within the context of previous thought, rather than viewing it in its own setting. As Freeman J. Dyson recently observed,

> The reason why new concepts in any branch of science are hard to grasp is always the same; contemporary scientists try to picture the new concept in terms of ideas which existed before.

There is no easy way of overcoming this obstacle and creating a more favorable climate for unbiased consideration of the nature and merits of the innovation. About the most that one can do is to define the new concept clearly: to explain specifically just what it is, where it is introduced into the previously existing system of thought, how it differs from previous patterns of thinking, and above all, to make it clear that however strange this concept may seem to first acquaintance, it is nevertheless logical and rational. Before taking up any questions of detail, therefore, I want to make a few comments of this kind about the new ideas that I am introducing.

The basic innovation in my new theoretical system, the Reciprocal System, as I call it, is a new concept of the nature of space and time which has emerged from a long and intensive study of basic physical processes. In present-day thought, a location in space is generally conceived as an entity that can be described by means of Cartesian coordinates. Of course, we cannot see a location in space, but we can see an object which may occupy such a location and we apply the coordinates to the object. If this object remains in the same spatial location its coordinates, according to the usual concept of space, are considered to remain unchanged. It should be realized, however, that this generally accepted concept of spatial localization is not something that has been derived from physical observation or measurement; it is a *geometrical* concept—purely a human investigation—and there is no assurance that it has any physical meaning or that it corresponds to anything that exists in the physical universe.

For example, if a *physical* object existing in *physical* space has no independent motion of its own and must therefore remain stationary with respect to that physical space, we have no assurance whatever that its geometrical coordinates will remain constant. It is normally taken for granted that such will be the case, and it must be conceded that established habits of thought make it rather difficult to visualize anything different. Einstein, for instance, says that it took him seven years of study and reflection to see this matter in a clear light and to realize that a physical location might not necessarily be capable of representation by a fixed geometrical coordinate system. After coming to this realization, however, he recognized its importance and he eventually utilized it as the basis of his General Theory. In that theory the coordinate system of reference is just as impermanent and subject to modification as the measurements with respect to the reference system are in the Special Theory. As explained by Moller in his textbook on Relativity,

> the spatial and temporal coordinates thus lose every physical significance; they simply

represent a certain arbitrary, but unambiguous, numbering of the physical events.

What I have done in distinguishing between physical space and geometric space is thus not entirely without precedent. Einstein has already made it clear that the common assumption that they are identical is untenable. But the relation between Einstein's physical system of reference and the geometrical system of coordinates is rather vague and dependent on local factors. There is no reason, he contends, why there should be any specific relationship between differences of coordinates and measurable lengths and times. As a result his system is extremely complex mathematically and almost impossible to check against observational data except in certain artificially simplified situations. On the other hand, the relation between my physical system of reference and the geometrical system is specific and definite under all conditions, and it is therefore possible to convert values from one of these systems to the other by relatively simple mathematical processes.

When viewed from the standpoint of a fixed geometrical system of reference, each location in the physical space defined by my postulates moves outward from all other locations in space at unit velocity—one unit of space per unit of time. Any physical object without an independent motion of its own remains in the *same location in physical space* permanently, but the spatial locations themselves move with respect to the geometrical coordinate system, carrying with them whatever objects exists at these locations, hence such objects move steadily outward away from each other when viewed from a fixed reference system.

According to this new concept, a location in physical space is a specific and definite entity, but it cannot be defined by static coordinates in the manner in which we define positions in geometric space. Physical space, the space which actually exists in the physical universe, and which enters into physical events and relations, is a dynamic entity, analogous to an expanding balloon, or more accurately, since it is three-dimensional, to an expanding solid rubber ball. Physical objects that are located in that physical space may have independent motions of their own, just as particles might move about on the surface of a balloon or through the voids in the structure of a rubber ball, but irrespective of whether or not they are moving in this manner, each of the objects is continually moving away from all others because of the continuous expansion of space.

Of course, this new concept of physical space as an entity in motion is so foreign to current thinking that it seems very strange on first acquaintance, but it is nevertheless obvious that it is a wholly rational hypothesis. Furthermore, the postulated expansion, or progression, of space is something that can be observed directly. As pointed out earlier, the identification of physical space with geometric space in current practice is not something that has originated from physical observation; it is purely hypothetical. To be sure, there are objects in the local environment which for extended periods remain stationary with respect to a geometrical system of reference, but these are not objects without independent motion. On the contrary, each of them has a whole system of motions. They participate in the rotation of the earth, in the earth's motion around the sun, in the motion of the solar system around the center of the galaxy, and in an unknown amount of motion of the galaxy itself, in addition to which they are subject to the influence of gravitation, which affects the motion of these objects to an unknown degree. It is possible, however, with the aid of today's powerful instruments, to see objects which are so distant that any motions of this nature which they may possess are negligible (that is, unobservable) and the effect of gravitation is attenuated to the point where it is no longer a significant factor. Under these conditions the new theory says that we should find these objects being carried away from us and from each other at extremely high velocities by the progression of physical space. This is exactly what the astronomers tell us that they see when they observe the most distant galaxies within reach of their giant telescopes.

It is important to realize that the motion due to the progression of space is something of an entirely different character from the independent motions of the objects that exist within the expanding system. If there are three objects A-B-C in a line, an object B moves *away from* A in the normal manner, it moves *toward* C. This is a directional motion: a vectorial motion in three-dimensional space. But if these are three objects that are being carried outward by the progression of space—three galaxies, let us say—then the motion which carries object B *away from* A moves it *away from* C as well. In the case of the motion is outward away from *all* other locations, hence it is *scalar*: a motion with no specific direction.

Astronomers recognize that the motion of the distant galaxies has this scalar character, and they frequently use the analogy of the expanding balloon, but in current thought this galactic motion is regarded as a unique phenomenon requiring a special explanation of its own, whereas in the Reciprocal System this is merely one manifestation of a *general* phenomenon which is encountered in a wide variety of circumstances throughout the universe. According to this new system of theory, *any* physical object which has no independent motion of its own will move outward in the same manner unless it is restrained in some way. Many of the most important of the new conclusions reached in the development of the Reciprocal System have originated from the discovery that certain phenomena hitherto regarded as involving ordinary vectorial motion are actually manifestations of scalar motion of the progression type.

A related point of major significance to physical theory that is brought out clearly by the balloon analogy is that the datum from which all physical activity extends is not zero but the speed of the expansion. It is evident that if we are concerned with the magnitude of the independent motion of a particle on the surface of the balloon, it is not the measured speed that is significant; the meaningful quantity is the difference—plus or minus—between this measured speed and the speed of the expansion. Similarly, the significant quantity in the physical universe is the deviation from the speed of the expansion (the speed of light), not the deviation from zero.

Here is one place where the new theory leads to some modification of previous mathematical relations, but it should be understood that the *essential* difference between the new theoretical system and previous scientific thought is *conceptual*, not *mathematical*. The requests that are frequently made for a mathematical statement of the new theory are therefore meaningless. To illustrate this point, let us give some further consideration to the outward movement of the distant galaxies—the galactic recession. There are two theories of this recession currently in vogue among the astronomers: the "big bang" theory, which attributes the existing galactic velocities to a gigantic explosion that is presumed to have taken place billions of years ago, and the "steady state" theory, which postulates that the galaxies are being pushed apart by new matter that is being created in inter-galactic space. To these I have now added a third. My new theoretical system says that the galaxies are actually stationary in physical space (except for some random motions that are too small to be observed), but that they are being carried outward with reference to fixed geometrical coordinates because physical space itself is an expanding system.

So far as the galactic recession itself is concerned, there is no significant mathematical difference between these explanations and hence there is no mathematical basis for preferring one of them over another. The real test of the relative power of these different hypotheses is the extent to which they are able to throw additional light on related questions, and for this purpose it is the *interpretation* that we put upon the mathematical expressions—our concept of the *physical nature* of the recession—that is significant. Mathematical reasoning or manipulation of symbols cannot take us beyond the bounds that are set by our concepts of the physical realities that are represented by the mathematical expressions or symbols, and in the case of present-day theories of the galactic recession these boundaries are narrow indeed.

But when we turn to the new concept of the recession that is supplied by the Reciprocal System we find that this opens up an immense new field for investigation. One very important point which immediately becomes obvious is that *on the basis of this concept both the recession and the inverse of this phenomenon may occur coincidentally*. This is not possible in a universe that behaves in accordance with current cosmological theories. We obviously cannot have the explosion postulated by the "big bang" theory and the reverse process—an "implosion" as it is sometimes called—going on simultaneously. Before the idea of concurrent inward and outward motions could be conceived at all, it was necessary to have a totally new concept of the nature of the recession, such as that which has been provided by the Reciprocal System.

If, as that system contends, objects with little or no independent motion, such as the distant galaxies, are being carried outward by the progression of space itself, then it is clearly possible for objects which *do* have substantial independent motions to move in the direction opposite to the progression of space, and thus move steadily inward toward each other. Such objects will then appear to be exerting forces of attraction upon each other, but because they are actually independent scalar motions rather than forces they will have some extraordinary characteristics, quite unlike those of the forces of our everyday experience. In particular, they will act instantaneously, without an intervening medium, and in such a manner that they cannot be screened off or modified in any way. All of these are, of course, the observed characteristics of gravitation, and it is apparent that the behavior of aggregates of matter in the observed physical universe agrees exactly with the theoretical behavior of objects that have independent motions in the direction opposite to that of the space progression.

We thus find that by a purely *conceptual* change—a modification of our ideas as to the fundamental nature of space—without any alteration of previously established mathematical relationships, we are able to extend our explanation of the galactic recession to apply to gravitation as well, thus bringing these two important physical phenomena within the scope of the same general theory. So it is throughout the universe. Each advance of this kind that we make with the aid of the new concept of the nature of space opens the door to further advances in related fields. Identification of gravitation and the galactic recession as two manifestations of the same basic phenomenon leads immediately to complete and consistent answers for many of the most serious problems that now confront the astronomers—explanations of the origin of galaxies, the stability of the globular clusters, the immense distances between the stars, and so on. Then further development along the same lines enables clarification of relations in areas that lie farther afield, such as the cohesion of solids and liquids, for instant. Thus a whole theoretical universe gradually emerges as we build item by item on the new conceptual foundation.