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INVITATION TO SEEK NEW PHYSICAL TRUTH

The Reciprocal System sheds new light on the doppler shift, on stellar energy generation, on ball lightning and on the expediency of reference frames to analyze adequately motion, as this issue discloses to the reader of RECIPROCITY.

We of NEW SCIENCE ADVOCATES, INC., publisher of RECIPROCITY, are a group of scientists and philosophers who recognize the great potential value of D. B. Larson's Reciprocal System of physical theory. Here is something totally UNPRECEDENTED: a GENERAL physical theory, one which derives ALL of its conclusions in ALL physical fields from a single set of basic premises.

Many persons have questions about the Reciprocal System of theory that they would like to discuss with someone. We of NSA and RECIPROCITY do not all claim to have a full grasp of all aspects of the theory, nor do we necessarily accept every conclusion that Larson and his fellow advocates of the Reciprocal System have reached. But we are organized to inaugurate THE RECIPROCAL CORRESPONDENCE CLUB (RCC) to enable every newly interested person together with ourselves to explore further the magnificent potential and detailed implications of new physical truth, the Reciprocal System. You do not have to
Join NSA to belong to THE RECIPROCAL CORRESPONDENCE CLUB (RCC) and enjoy its services. If you are interested in having persons to correspond with about the Reciprocal System, simply write to Mr. Satz, Professor Meyer or Dr. Huck at his respective address on the masthead of the current RECIPROCITY and you will be put in touch with your correspondents and also receive a free copy of RECIPROCITY. By sending $2.00 with your letter you will receive also the coming issues of RECIPROCITY for 1978.

Forthcoming Publication About Reciprocal System

We of NSA eagerly anticipate the coming publication of the first volume of the revised edition of the original basic work about the Reciprocal System, THE STRUCTURE OF THE PHYSICAL UNIVERSE, published in 1959 but now out of print. When available under the revision title, NOTHING BUT MOTION, readers of RECIPROCITY will be called on to publicize and support this important publishing event. The second Annual NSA Conference in Oxford, Mississippi, August, 1977, adopted this project as a major current NSA objective. NSA members and friends of examining the Reciprocal System are invited to forward suggestions how best to advance this mighty objective.

Compared with the Reciprocal System, no previous theory comes anywhere near being a general theory in the true sense of the term. None of them is applicable to more than a relatively small part of the physical universe, and none is derived entirely from premises of a general nature. Everyone finds it necessary to make many assumptions specifically applicable to its restricted field of coverage. A theory of electrical phenomena makes assumptions about electricity and electric charges; a theory of quasars makes assumptions about quasars and about the radiation through which these objects make themselves known and so on. Furthermore, all of these theories make use of a host of additional assumptions of a more general character that are embodied in the basic laws and principles of physics. But now we have a theory that makes no assumptions at all, other than those contained in the fundamental postulates as to the properties of space and time which define the theory. ALL conclusions, including those with respect to the basic physical laws and principles, are derived solely by deduction from those postulates, without invoking the aid of ANY supplementary assumptions, and without introducing anything from experience.

This totally unprecedented accomplishment is sufficient in itself, in our opinion, to justify the most serious and painstaking study of the new theoretical structure whatever the initial emotional reaction to the nature of some of the conclusions may be. There is a widespread tendency to elevate the popular ideas of the moment to the status of unassailable dogma, and to reject summarily anything that conflicts with them, but the mere existence of serious problems in many physical areas shows that some basic changes are inevitable. Whether or not the changes that the new theory calls for will ultimately prove to be the ones that are required remains to be seen, but it is significant that, within the range of phenomena thus far covered in the development of the details of the theory, an area which includes the basic features of all the major branches of physical science and a wide variety of subsidiary phenomena, all of the conclusions that have been reached from the theory are consistent with the physical FACTS that have been definitely established by observation or measurement (although they do not necessarily agree with all inferences from, or extrapolations of, those FACTS, nor with the theories previously devised to explain the FACTS).

It is also highly significant that the changes in physical thought which this new development finds necessary are CONFINED almost entirely to those regions in which a correct theory MUST make some changes: those regions in which current theory is encountering serious difficulties—the "elementary particles," the extremely compact
astronomical objects, and similar baffling phenomena of the very small, the very large and the very fast. Then, too, the new theoretical system is able to deal successfully with the "islands of ignorance" that have been left behind in the general advance of scientific knowledge. It not only arrives at new answers of a logical character for a number of basic questions that have never been fully resolved on the basis of previous theory—the origin of gravitation, the mechanism of the cohesion of solids, the source of cosmic rays, etc.—but also provides answers to some questions that have heretofore been regarded as unanswerable, or even meaningless. The questions, what is electricity? and/or what is light? are good examples.

Of course, there is no general agreement as to what constitutes a fully satisfactory "explanation" of a physical phenomenon, but here, again, the unique character of the Reciprocal System of theory clarifies the situation. The underlying concept of this system is that of a physical universe composed ENTIRELY of discrete units of motion, and the theoretical development based on this concept identifies ALL physical entities and phenomena as specific kinds of motion, combinations of motions, or relations between motions. All that is necessary in order to provide a full explanation of anything of a physical nature in the context of this system of theory is to specify just what kind of a motion, or aspect of motion, this "something" actually is.

We of NSA believe that everyone who has anything more than a casual interest in science or the philosophy of science ought to take the time to become acquainted with this new theoretical system which, in our opinion, is the physical theory of the FUTURE, or at least contains the seeds from which that theory will grow. It should have a special significance for those engaged in the fields such as astronomy or particle physics where new avenues of approach to the subject matter are so obviously needed. The essential point here is that the conclusions that are set forth in D. B. Larson's works with respect to sub-atomic phenomena, quasars, pulsars, and the other major scientific enigmas of the moment, are not products of a fertile imagination; they are logical or mathematical deductions from the basic postulates that define a universe of motion, and they are totally independent of observation. Such a purely deductive theoretical system is equivalent to a new instrument of exceptional power and versatility, an instrument that it is now at your service.

If you wish to inquire in order to learn whether now the Reciprocal System is where the search for new physical truth is at, it is easy to find out: by joining RCC without any obligation except to participate in discussion of the issues with other interested persons, with which our NSA organization will put you in touch for the asking.

If you have been receiving RECIPROCITY regularly, the Editor would appreciate your letting him or the NSA Secretary know by post card whether or not you wish to continue receiving it in 1978.

NSA members who wish to renew membership but have not done so for 1978 should send $10 annual dues (tax deductible) to NSA Treasurer. Plans are afoot to launch NSA Chapters in as many of the 50 States of the U.S.A. as presently possible and your continued support and aid is sought and welcome.
BALL LIGHTNING
by
Dr. Rainer Huck
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Introduction

Of all the forms of lightning, ball lightning is, beyond any doubt, the most rare and mysterious. Even though it was discussed by Aristotle in the 4th century B.C. in his work on meteorology, and has, in the intervening years been reported by thousands of reliable observers, it has only recently gained acceptance as a real phenomenon by the majority of scientific authorities. A survey conducted at the Oak Ridge National Laboratory in 1960 by J. Rand McNally, Jr. asked 15,923 employees if they had witnessed ball lightning, resulting in 515 positive replies. Sufficient evidence has now been accumulated to form a fairly compelling case for the existence of ball lightning, although its characteristics are such that no theory thus far submitted provides a satisfactory explanation.

General Characteristics

One of the likely reasons that theories devised to account for the existence of ball lightning have met with little success is perhaps because of the many and varied ways it manifests itself. It can range in size from a few centimeters to well over one meter, but is most commonly seen in the 20-30 cm range. It takes on a broad spectrum of colors including red, orange, greenish blue, and even white. It has been seen to be nearly spherical in shape but is more often oblate, with boundaries that may be either sharply defined or hazy and indistinct. Sometimes ball lightning is seen to have protrusions issuing from the main mass and/or sparks flying away from it. It often makes a hissing or crackling sound but many times has been reported to be completely silent.

It can be seen to move through the air, seemingly at will, without regard to direction, yet sometimes seems to be constrained to move along a conductor such as a rain gutter or an electric wire. In addition, it can hang motionless, even in the presence of winds. In most cases ball lightning does not seem to radiate heat yet can explode or scorch walls or floors, indicating the presence of substantial internal energy, and has, on occasion, resulted in injury and loss of life. The death of Prof. G. W. Richmann in 1753 has been attributed to a contact with ball lightning. It has been seen descending at varying rates of speed from storm clouds but is most often noticed near the ground in the vicinity of an atmospheric electrical discharge.

Eyewitness Reports

Perhaps the best way to gain some familiarity with the behavior of ball lightning is to study a number of eyewitness accounts. Only a few representative cases are given here; the interested reader should refer to Singer for additional information.

The most common type of ball lightning observations are those wherein the phenomenon is first seen shortly after its formation. This usually occurs in conjunction with an electrical storm, although this is by no means always the rule, as is shown by the fourth example.
"In the summer of 1943 in the United States an engineer finished taking a shower on the second story of a wooden house during a short rainstorm. He heard thunder and saw a 30 to 45 cm diameter ball, bluish in color, float through a window screen at the end of the hall. It passed through the 9 meter long hall in 3 to 4 seconds and then went out a screened window at the other end of the hall. As it floated by him at waist height he felt no heat but smelled the odor of ozone."  

"During a short violent storm in Germany in 1905 a bright ball lightning approximately 20 cm in diameter formed. After a moment in which it remained stationary, it moved in a straight line downward, accompanied by a faint noise like that of an electrical discharge. On its left side were small protrusions from which shadows moved over the surface, indicating a rotational motion. After 5 or 6 sec. it exploded illuminating the nearby region with a red light."  

"A dull red, pair-shaped fireball floated slowly from an enclosed room with 2 ft. thick walls used as a drying oven. Short streamers of red flame flared out from it in all directions. It passed across a wooden landing, over the top of a truck, and exploded 1 meter from the ground... There was no sign that anything had penetrated the wall at that point into the room where the fireball started."  

"Four men had resumed their work in construction of a wall following a rainstorm in Germany in 1868. The sun was shining, and in the blue skies there were only a few almost transparent clouds. The men were about to lift a stone approximately 80 cm square to the wall. They were standing around the stone when suddenly there was a flash of lightning; in the middle, approximately 90 cm above the stone, a round, yellow, transparent ball of about 20 cm diameter appeared, steadily moving up and down for a distance of 4 cm. In the center of the ball was a bluish flame which was pear-shaped with the point downward and 4 cm in length. The flame revolved in a vertical circle of 7 cm diameter inside the large ball. A sharp crack was heard after a few seconds, and the ball lightning disappeared."  

In a few rare cases observers have actually witnessed the formation of ball lightning. Singer reports such an instance in which ball lightning seemingly originated in a sharp bend in a zigzag lightning flash. In another case:

"...the witness noted a snake-like discharge descending extremely slowly to a telegraph pole during a heavy rain. It came to a halt approximately one meter above the pole and formed a ball one-third meter in diameter which exploded with such a crash that several people rushed out of doors to see what had happened."  

**Artificial Generation of Ball Lightning**  

From a consideration of cases of the type discussed above it would seem that ball lightning is generated only in conjunction with electrical disturbances of great magnitude. A number of instances have been reported, however, wherein a seemingly genuine ball lightning has been generated by artificial means and in the presence of much lower energy levels. The earliest such case concerns the generation of ball lightning in a Leyden jar sometime in the eighteenth century.
"A ball of fire like a red-hot iron ball approximately 2 cm in diameter and rotating rapidly was seen in a Leyden jar as it was being charged. Suddenly there was a loud explosion accompanied by a bright flash, and the glass of the bottle was pierced by a circular hole."

In 1889, in his Colorado Springs laboratory, Nikola Teska, to whom we are all indebted for the development of the Tesla high frequency induction coil, claimed that he was able to develop balls of electrical energy some two and one-half inches in diameter. The December 1919 issue of radio amateur magazine, QST, contained a letter to the editor by two ham radio operators in Chattanooga, Tenn., which claimed that they accidentally generated a ball of lightning with their radio apparatus. More recently, such a manifestation is seen approximately once a year at the Hill Air Force Base Missile Radiographic facility in Utah. Volleyball size fireballs are seen to drop out of the air from the vicinity of a high voltage supply for the 25 MeV linear accelerator. Unfortunately, no one has as of yet been able to design a repeatable experiment which gives rise to a ball lightning manifestation under controlled conditions. It seems that in each of the above cases there existed some unknown or hidden variables which by chance had obtained the correct value, in conjunction with the conditions that were known, to generate the phenomenon.

Theories

There has been no shortage of theories put forth in an attempt to render understandable the complex phenomenon of ball lightning. These theories include chemical reactions, nuclear reactions, molecular ion interactions, vortices, electrical discharges, and, more recently, plasmas. A summary and discussion of these theories and more is given in Singer.

Discussion

Ball lightning has inspired considerable surges of theoretical activity throughout its history. The apparent lack of any successful explanation may be due to one or more of the following causes:

1. Ball lightning is not a genuine physical phenomenon.
2. The theorists have not worked hard enough, and need more time.
3. The manifestation is a consequence of factors that are not embraced in the structure of contemporary physical theory.

If the latter possibility (number 3) should be applicable in this case, it would seem that the development of a theory elaborating the characteristics of ball lightning would be a suitable undertaking for those interested in expanding the scope of the Reciprocal System. Such a theory could be easily tested through its ability to identify the hidden variables that have prevented repetition of the accidental instances of artificial generation of ball lightning.

On the experimental front, an industrious electrical engineer, Robert Golka, has secured a grant from the U.S. Air Force and is currently working at the Wendover Air Force Base in Utah toward the artificial production of ball lightning. He is attempting to reproduce the Tesla technique using a 25 million volt coil of his own construction. It is his belief that a thorough understanding of the nature of ball lightning may stimulate a significant advance toward the use of atomic fusion as a practical energy source.
Given below is a rather general flow chart of a possible mechanism for ball lightning. Anyone with an interest and a background in a related area should be encouraged to give this matter some thought.

Electric potential → Source particles → Ball lightning

Special conditions → Interaction with local environment

Bibliography

4. Ibid, p. 29.
5. Ibid, p. 35.
7. Ibid, p. 34.
8. Ibid, p. 95.
9. Ibid, p. 27.
10. Ibid, p. 79.

Dr. D. W. Swan
Letter about Quantized Time
Physics Bulletin, July, 1977

It is interesting to see that the idea of quantized time should now be arousing interest, and it is worth pointing out that this concept was developed in considerable detail by Larson nearly 20 years ago (THE STRUCTURE OF THE PHYSICAL UNIVERSE, published by D. B. Larson, and a number of other books by the same author published by North Pacific Publishers, Portland, Oregon). He showed that the consequences of this different way of looking at time were such that physical theory would have to undergo a complete over-haul, a postulate that effectively eliminated any chance of his work being considered seriously by the establishment. Perhaps in these days, when physicists are not quite so confident about some of the foundations, Larson's theory might be reappraised.

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The Doppler Shift and the Reciprocal System

by

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Let us suppose there is an object traveling away from us at a uniform straight-line speed of \( v_{BA} \), where \( v_{BA} \) is expressed as a fraction of the speed of light. Suppose the object emits a photon of frequency \( f_B \) relative to itself which travels in our direction. What will be the frequency \( f_{BA} \) which we will measure when we receive the photon?

In the classical approach, we assume the period of the photon relative to the emitter B is \( 1/f_B \); that is, it takes a time of \( 1/f_B \) to complete a cycle. During this cycle the photon travels a distance of \( (1/f_B) \times c \) with respect to B, where \( c \) is the speed of light. This distance is the wavelength of the photon with respect to B, or \( \lambda_B \). Since, however, we are expressing all speeds as fractions of unity, we have \( c=1 \), and the wavelength becomes:

\[
(1) \quad \lambda_B = \frac{1}{f_B}.
\]

If we wish to determine the classical value for the received wavelength, \( \lambda_{BA} \), we must substitute \( \lambda_B \) for \( \lambda_B \) in the space equation of the Galilean transformation (2):

\[
(2) \quad x_A = x_B + v_{BA}t_B.
\]

Working the aforementioned substitution gives (3):

\[
(3) \quad \lambda_{BA} = \frac{\lambda_B}{1 + v_{BA}}.
\]

Now we recall that, in the Galilean scheme, \( t_B = t_A \). Furthermore, in this particular example, \( t_B = \frac{1}{f_B} \times \lambda_B \), so (3) becomes:

\[
(4) \quad \lambda_{BA} = \frac{\lambda_B}{1 + v_{BA}}.
\]

Keeping in mind that frequencies are inversely proportional to wavelengths, and making the appropriate algebraic manipulations, we arrive at (5):

\[
(5) \quad \frac{f_B}{1 + v_{BA}} = f_{BA}.
\]

Finally, by solving (5) for \( v_{BA} \), we obtain the classical formula (6) for speed in terms of redshift:

\[
(6) \quad \frac{f_B}{f_{BA}} - 1 = v_{BA}.
\]

Conventional theoretical physicists, however, do not accept (5) as a correct means of deriving the speed of an object from its redshift. They are in the habit of using classical concepts to solve physical problems, but substituting the Lorentz transformations for the
Galilean ones whenever a transformation of some sort is needed. It is true that Einstein might not have approved of such a "hybrid" approach, for he claimed to have found a new set of concepts uniquely suited to the Lorentz transformations; but from the standpoint of the Reciprocal System the modern approach is quite understandable. The Reciprocal System contends that the Lorentz transformations are indeed the numerical adjustments needed to reconcile the observed phenomena with formulas derived from the classical idea that clock time is total time.

Following this modern approach then, we will retrace steps (1) through (6) above, blindly substituting the Lorentz transformations wherever the classical derivation used the Galilean ones.

The first adjustment needed is to equation (2), which now becomes (2'):

\[ x'_A = \frac{x_B + v_{BA}t_B}{(1-v_{BA}^2)^{1/2}} \]

Equation (3) now becomes (3'*):

\[ W_{BA} = \frac{W_B + v_{BA}t_B}{(1-v_{BA}^2)^{1/2}} \]

Again recalling that \( t_B = \frac{1}{f_B} = W_B \), we obtain (4'):

\[ W_{BA} = \frac{W_B(1+v_{BA})}{(1-v_{BA}^2)^{1/2}} \]

Since frequencies are inversely proportional to wavelengths, we get:

\[ f_B(\frac{1-v_{BA}^2}{1+v_{BA}})^{1/2} = f_{BA} \]

Finally, solving for \( v_{BA} \), we get

\[ \frac{f_B^2 - f_{BA}^2}{f_B^2 + f_{BA}^2} = v_{BA} \]
Formula \((6')\) above is the relativistic formula relating frequency to speed. As we have said, this formula is arrived at simply by substituting the modern for the classical transformation formulas. From the standpoint of the conventional physicist, this merely amounts to assuming that the space adjustment of the Lorentz transformations applies to wavelengths just as much as to any other physical phenomenon. This is not the result of treating light as if it were analogous to matter; rather it is the result of treating the coordinate system itself as if it were some sort of universal physical "object" whose "contractions" affect all other physical objects equally. It is quite in line with the modern practice of elevating coordinate systems in general to the position of fundamental physical entities, even while denying that status any particular one.

... Some students of the Reciprocal system might also accept \((6')\) instead of \((6)\), but for a different reason. They would assume that every high-speed situation involves a discrepancy between clock time and total time, and hence that the Lorentz transformations can always be used. But plausible though this reasoning might seem, it is not valid in the Reciprocal system.

The Reciprocal system regards the classical doppler shift formula as the correct one. In other words, it contends that when photon frequencies are involved, clock time is always equal to total time, even at high speeds.

To understand just why this is so, it will be necessary to derive the classical doppler formula once more, this time using the concepts of the Reciprocal system. The key to this derivation will be the Reciprocal system's theory of ordinary translational motion.

Both the classical and modern conventional physics hold that translational, or "straight-line", motion can occur at any speed between zero and unity. The Reciprocal system, on the other hand, contends that ordinary translational motion is subject to quantization in the same manner as any other motion. In other words, all translational motion actually takes place at the speed of light, and it is only because of periodic reversals of direction along the line of motion that the average speed of such motions falls below unity.

If a given translational motion moves \(P\) units forwards (away from us) at the speed of light, and then \(Q\) units backwards, the total number of units of time involved in the forward-and-backward cycle will be \(P+Q\), because of the one-to-one ratio of space and time. The net advance in space will be \(P-Q\). Thus the average speed of a translational motion which consists of such cycles will be:

\[
(7) \quad v_{BA} = \frac{P-Q}{P+Q}
\]

It is not clear to the author that \(Q\) in the above equation could ever have any other value than unity, but for the purposes of this paper, the more general formulation will suffice.

Not let us suppose that an object moving away from us with a speed \(v_{BA}\) as described by \((7)\) is emitting photons of wavelength \(\lambda\) toward us. Here \(\lambda\) is the wavelength with respect to the emitting object.
During the "forward" phase of the emitting object's motion, the wavelength relative to us will be $\lambda_{BA} = 2\lambda_B$, because the photon is moving away from us at the speed of light. Since there are $P$ such steps away from us in a forward-and-backward cycle, the total space taken up such wavelengths in the cycle is $2P\lambda_B$.

On the other hand, during the emitter's "backward" phase, both the photon and the emitter are traveling toward us at unit speed; that is, photons are not being emitted at all. Thus the received wavelength is zero.

The average received wavelength per unit of time during one cycle therefore will be:

$$\lambda_{BA} = \frac{2P\lambda_B}{P+Q}$$  \hspace{1cm} (8)

Equation (8) may be rewritten as follows:

$$\lambda_{BA} = \lambda_B \cdot \frac{P+Q-P-Q}{P+Q}.$$  \hspace{1cm} (9)

Substituting (7) into (9) and simplifying, we obtain:

$$\lambda_{BA} = \lambda_B (1 + v_{BA}).$$  \hspace{1cm} (10)

This is equation (4) all over again. Since the Reciprocal system's method yields the same result as the classical one, this is equivalent to saying that, in this case, clock time equals total time.

Now we will wish to see how the Reciprocal System compares with conventional theory in explaining the various natural phenomena which involve redshift.

To do this, it will be necessary to rewrite equations (6) and (6'); for the same value of $f_B$ and $f_{BA}$ on the left side of these equations will give different values for $v_{BA}$ on the right. Let us, then, call the value yielded by the left side of (6) the reported Doppler shift, $D_{BA}$, and that yielded by the corresponding side of (6') the Einsteinian value, $E_{BA}$. Thus we get equations (11) and (11'):

$$\frac{f_B}{f_{BA}} - 1 = D_{BA},$$  \hspace{1cm} (11)

$$\frac{f_B^2 - f_{BA}^2}{f_B^2 + f_{BA}^2} = E_{BA}.$$  \hspace{1cm} (11')

Solving for $E_{BA}$ in terms of $D_{BA}$ we obtain (12):

$$\frac{(D_{BA}+1)^2 - 1}{(D_{BA}+1)^2 + 1} = E_{BA}. $$  \hspace{1cm} (12)
One immediate application of (12) is to the redshift of quasars. The reported redshifts $D_{BA}$ of quasars and similar objects are generally well above unity, whereas those of "normal" galaxies are generally well below this figure. In conventional physics, the speed of an object whose reported redshift is unity is computed by substituting unity for $D_{BA}$ in (12). The result is three-fifths the speed of light; a figure to which conventional physics attaches no special meaning.

In the Reciprocal System, however, the redshift of an object is its speed relative to light. Since quasars have redshifts greater than unity, they must be, in some sense, traveling at faster than the speed of light, and hence it is no wonder they have "funny" properties.

This is not the place, however, to discuss the properties of quasars in detail. Interested readers may turn to the book Quasars and Pulsars, by Mr. Dewey Larson, for further information. The book is published by North Pacific Publishers of Portland, Oregon.

Instead, we will turn to a consideration of the various terrestrial experiments which purport to prove the validity of the relativistic formula (6').

First of all, we must note that it is impossible for an experiment, by itself, to prove anything. The logical structure of an experiment is as follows:

\[
\text{assumptions} \rightarrow \text{experiment} \rightarrow \text{conclusion}.
\]

If no assumptions have been put into an experiment, no conclusion can be drawn from it, unless the conclusion is so limited as to be a mere restatement of the datum the experiment has yielded. All that an experiment can do on its own is disprove a given theory.

Keeping this in mind, the first terrestrial Doppler-shift experiment we will look at is the Ives-Stillwell experiment of 1938. The experiment is described on pages 215-226 of volume 28 of the Journal of the Optical Society of America.

The experiment consisted of measuring wavelengths of the H$eta$ line of hydrogen canal rays at various voltages both in the direction of motion and in the contrary direction. The experimenter then took the average of the resulting Doppler shifts and compared them with the average values predicted through the use of (5'). By average here we mean the average of the shifts observed in opposite directions.

The "predicted value" for this average, using (5'), is

\[
(13) \quad 1/2 \left[ \frac{f_B (1-v_{BA}^2)^{1/2}}{1+v_{BA}} + \frac{f_B (1-v_{BA}^2)^{1/2}}{1-v_{BA}} \right] = \frac{f_B}{(1-v_{BA}^2)^{1/2}}
\]

For moderately small values of $v_{BA}$, the right side of 13 is approximately equal to $X$ in the following equation (14):

\[
(14) \quad X = 1/2f_B v_{BA}^2.
\]
Table III on page 225 of the aforementioned article by Ives and Stillwell gives a comparison of the measured redshifts with the values predicted by the approximate equation (14). The values would appear to agree to within two or three percent. Thus, in a subsequent article in the same Journal, the experiments conclude: "The net result of this whole series of experiments is to establish conclusively that the frequency of light emitted by moving canal rays is altered by the factor \((1-v^2/c^2)^{1/2}\)."

But if our understanding of the logical structure of experiments is correct, this "conclusion" must be based on some assumptions; and, indeed, we have not far to look to find at least one. The aforementioned quotation concerning the "conclusiveness" of the experiment in question, found on page 374 of volume 31 of the Journal, is immediately followed by this statement: "This agrees with the prediction of Larmor and Lorentz... unless such a frequency change should be shown to be the result of other factors than the speed of the particles...". In other words, the result could be due, for example, to the high energy of the hydrogen ions, in much the same way that the stable form of molecular oxygen, ozone versus diatomic oxygen, is supposed to depend on the prevailing energy levels. The assumption that this is not the case amounts, in the author's opinion, to assuming the existence of a time-dilation factor.

In fact, although modern textbooks represent the Ives-Stillwell experiment as a decisive comparison of the classical Doppler formula with the Lorentz one, there is evidence that the experimenters themselves never intended it to be that. The main article concerning the experiment (page 215, vol. 28) opens with the following words:

In previous papers in this series, various consequences of the alteration of the rate of a clock in motion... have been discussed. In these papers, this change in clock rate has of necessity been treated as an assumption, since, up to the present time it has not been the subject of independent experimental verification.

The "previous papers" referred to were by Herbert Ives and appeared on pages 177-180, 263-273, 310-313, and 389 of volume 27 of the same Journal. On page 179 of volume 27 we read:

Kennedy and Thorndyke actually performed their experiment as a test of the hypothesis of Larmor and Lorentz that a moving light source is reduced in frequency in the ratio \((1-v^2/c^2)^{1/2}\) ... The experiment is, however, equally well explained by assuming an unequal contraction of the apparatus in two directions, and no change in time reckoning.

(Letting \(x=(1-v^2/c^2)^{1/2}\), this)... line of analysis may be pursued further to yield the following formulae (describing possibilities consistent with the experiment):

\[ x^{n+1} \] for contraction in the direction of motion

\[ x^n \] for contraction at right angles to the direction of motion

\[ x^{1-n} \] for reduction in clock frequency.
In short, the purpose of the Ives-Stillwell experiment was to determine the value of the exponent n in the above equations; the experimenters were already convinced that some sort of space contraction and/or time dilation formula like the Lorentz transformations was required. This is why the conclusion to the principal (1938) paper reads, in part, as follows:

The null result of the (Kennedy and Thorndyke) experiment can be explained... by contractions of the apparatus along and across the direction of motion which are in a definite ratio to each other... from these experiments the contractions are unfixed in absolute amount... The present experiment establishes (the absolute amount of) this rate...

No wonder that the statement as to the "conclusiveness" of the experiment from the later (1941) paper seemed to include the assumption that some sort of dilation or contraction was required to begin with.

If Ives and Stillwell had wanted to make their experiment a genuine test of the classica versus the relativistic Doppler shift, they should have computed what the classical theory would have predicted for the outcome of their experiment. This would have meant, among other things, computing the possible effect of the earth's motion upon the motion of the hydrogen ions. An examination of Ives' 1937 papers on the theory behind the experiment, the ones appearing in volume 27 of the Journal, shows the experimenters never did anything of the sort.

We may add, in passing, that if all Ives and Stillwell wanted to do was establish the value of the exponent n in their equations, an experiment was unnecessary. It can be proven mathematically that under the assumptions Ives and Stillwell made, the only possible value of n can have is zero. A proof of this may be found in the book Space, Time and Relativity by Rolf Nevanlinna (Addison Wesley, 1967).

At any rate, whatever Ives and Stillwell's contemporaries may have thought of their experiment, later conventional physicists have not been entirely satisfied with it. This attitude can be seen in the article describing the next experiment we shall consider (Hirsch I. Mandelberg and Louis Vitten, "Experimental Verification of the Relativistic Doppler Effect", Journal of the Optical Society of America, vol. 52, no. 5, pages 529-536). The introduction to this article states in part,

An analysis of the experiments of Ives and Stillwell and of Otting indicates that although their reported experimental points seem to fit the curve with an accuracy of about 2 to 3%, the experimental uncertainty is more nearly 10-15%.

The article then goes on to describe the more accurate repetition of the Ives-Stillwell experiment which the authors undertook.

Since the Mandelberg-Vitten experiment is but a repetition of the Ives-Stillwell one, it is open to the same philosophical objections. We will not, therefore, discuss it in detail. We will, however, look at one methodological error common to both experiments.

If we subtract the two terms on the left side of (13), instead of adding them, we obtain \( \frac{v}{(1-v^2)^{1/2}} \), which, for small values of v, is approximately equal to v. So Ives
and Stillwell thought that by subtracting the shifts in opposite directions, they could obtain an estimate for the velocity of the emitting ions without having to compute it from the voltages used. (This, of course, was in addition to the average of the shifts in opposite directions which we have already discussed.) Mandelberg and Witten agreed with this idea.

But this reasoning is circular. The difference of the shifts will be approximately equal to v only if the law governing the shifts is approximately of the form lsv+f(v), where f is some function, and the sign in lsv depends on the direction of observation. (Actually, the l could be replaced by some other constant). This objection is not too serious in the case of the Ives-Stillwell experiment, as the experimenters there did also calculate v from the voltages involved, but it appears that Mandelberg and Witten did not.

Before concluding, we wish to mention the experiment of Hay, Schiffer, Cranshow and Egelstaff (Physics Review Letters, vol. 4, page 165, 1960). This was a resonance-absorption Mossbauer experiment which used a gamma-ray source mounted on the axis of a rapidly rotating cylinder with an absorber attached to the circumference of the cylinder. Here again, the experimenters claimed to find in the observed frequency shifts "proof" of the relativistic formula. The author, however, cannot comment at this time on the assumptions underlying the experiment, as he is still in the process of trying to locate all the papers involved, and of trying to acquire the necessary technical background to understand them. He would appreciate any help that readers might wish to offer in this area.

What, then, are the results of our survey of these experiments? First of all, do the conclusions of these experiments constitute a direct challenge to the Reciprocal System? The answer is, no. Because of the logical structure of experiments, these conclusions cannot have any relevance for the Reciprocal System unless the assumptions on which they were based are also compatible with the Reciprocal System. The Ives-Stillwell experiment, for example, assumed that observed frequency shift was due solely to the relative motion of the ions, and that the earth could be regarded as an inertial reference system. The first assumption is possibly, and the second one definitely, incompatible with the Reciprocal System.

Are these experiments decisive contests between the classical formula and the relativistic one? Again, the answer is no. The experimenters never computed what modifications, if any, would have to be made to the classical formula to take into account factors important in the classical theory, such as the motion of the earth.

Were the experiments technically correct? This question is still open.

How does the Reciprocal System explain these results? This question is also open. It is an important one, because until the Reciprocal System comes up with its own explanation, the possibility of a contradiction exists. Of course this can be said of any phenomenon which the System has not gotten around to explaining, but the Doppler shift experiments touch on very basic questions, and scientists are not likely to accept the Reciprocal System's formula if they believe that experiments have established a contrary formula. It is true that we have shown that these experiments have not disproved the classical formula, but our arguments are likely to be regarded as "carping" by the average scientist unless we come up with our own explanation of the facts.
The author would like to acknowledge the help of Ronald Satz of St. Louis Park, Minnesota, in locating some references used, and that of Dewey Larson of Portland, Oregon, for his informal discussion with the author of many of the issues covered in this paper.

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Author's Note: This paper is not meant to be the last word on subject of stellar energy. Rather it is meant only to be the second word. Constructive criticism would be welcome.

STEMLAR ENERGY GENERATION IN THE RECIPROCAL SYSTEM
by
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Transpower Corporation
St. Louis Park, MN

The theory of stellar energy generation in the Reciprocal System is stated qualitatively in various works by Mr. Larson, such as Quasars and Pulsars. For the benefit of new readers of Reciprocity, I quote Mr. Larson in full:

Inasmuch as a charge is a modification of the basic rotation, the number of charges that an atom can acquire, the degree 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 material 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 of the atomic structure. Since the maximum ionization 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 heavier atoms, and the effect is to establish a temperature limit for each element that is inversely related to atomic number. As the temperature of an aggregate rises, the heaviest elements are therefore the first to disintegrate.
To sum up, when the destructive thermal limit is reached, the following word equation holds true:

\[
\text{ionization energy of atom} + \text{thermal energy of atom} = \text{energy equivalent of one unit of magnetic time displacement (} \text{la} \]

Let \( E_I \) be the ionization energy, \( E_T \) be the thermal energy, and \( E_M \) be the oppositely directed magnetic rotational energy. Then in symbols,

\[
E_I + E_T = E_M \quad (\text{lb})
\]

Each of the terms in the equation will now be discussed.

Equivalent energy of one unit of magnetic time displacement

Before we can find the energy equivalent of one unit of magnetic time displacement, we must find the mass equivalent. According to deductions previously made from the postulates of the Reciprocal System, the electric equivalent of a magnetic displacement \( n \) is \( 2n^2 \); this does not refer to the total from zero to \( n \)--it is the equivalent of the \( n \)th term alone. Each electrical unit is equal to two atomic mass units, and each atomic mass unit is equivalent to 931.48 MeV. For \( n \) equal to 3 and 4, the following table results:

<table>
<thead>
<tr>
<th>( n )</th>
<th>( 2n^2 )</th>
<th>amu</th>
<th>( E_M ) MeV</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>18</td>
<td>36</td>
<td>33533.28</td>
</tr>
<tr>
<td>4</td>
<td>32</td>
<td>64</td>
<td>59614.72</td>
</tr>
</tbody>
</table>

Thus, the third magnetic time displacement is equivalent to 33533.28 MeV, and the fourth unit to 59614.72 MeV.

Ionization energy

At the present stage of development of the Reciprocal System we do not have a theoretical equation giving the energy needed to completely ionize an atom--but then neither does quantum mechanics. An empirical equation will have to do for now.

Reference three has the most comprehensive table of ionization values available, giving the complete ionization energy for the first twenty elements. From the values, I have derived the following empirical equation:

\[
E_I = 13.595 + 52.148(Z-1)^2 \times 10^{-6} \text{ MeV} \quad (2)
\]

where \( Z \) is the atomic number. Of course, other equations are possible. Extrapolating any empirical equation to high values of \( Z \) is risky, but this will have to do. For thorium, at. no. 90, eq. 2 gives

\[
E_{I_{\text{Th}}} = .413 \text{ MeV}
\]
Thermal energy

Let \( k \) be Boltzmann's constant in MeV/\(^0\)K and \( T \) be the temperature of an atom in \(^0\)K. Then the standard equation for the thermal energy (based on the ideal gas law) is

\[
E_T = \frac{3}{2} kT = \frac{m v^2}{2} = 1.292 \times 10^{-10} T \text{ MeV}
\] (3)

Calculation of critical temperature and velocity

From eq. 1b,

\[
E_T = E_M - E_I
\]

Then,

\[
T_{CRIT} = \frac{E_M - E_I}{1.292 \times 10^{-10}} \text{ } \text{ } \text{K}
\] (4)

For thorium, \( E_M \) is 59614.72 MeV and \( E_I \) is .413 MeV, so

\[
T_{CRIT_{Th}} = 4.61411049x10^{14} \text{ } \text{ } \text{K}
\]

This is fantastically high from our view as spectators on the earth, but in terms of natural units, the temperature is "only" 127.44.

With \( k \) in J/\(^0\)K, equation 3 can be solved for the velocity at the critical temperature.

\[
v_{CRIT} = \sqrt{\frac{3kT_{CRIT}}{m}}
\] (5)

For thorium, this amounts to

\[
v_{CRIT_{Th}} = 2.5289x10^8 \text{ m/sec}
\]

This is 84% of the speed of light!

For iron, the critical temperature is

\[
T_{CRIT_{Fe}} = 4.61413989x10^{14} \text{ } \text{ } \text{K}
\]
and the critical velocity is

\[ v_{\text{CRIT}}_{\text{Fe}} = 2.7165 \times 10^8 \text{ m/sec} \]

This is 91% of the speed of light! No wonder atoms are accelerated to velocities above the speed of light during a supernova explosion!

Most likely, the motion of the atoms in the core of a star is circular. The greater the temperature, the higher the velocity--thus, as theoretically expected, O and B type stars have much greater rotational velocities than G and K type stars.

Rate of energy generation

Since both the unit of magnetic time displacement and the opposing space displacement revert to linear motion, the total energy radiated per critical atom is

\[ E_{\text{RAD}} = 2xE_M = 119229.44 \text{ MeV} \]  \hspace{1cm} (6)

for \( n = 4 \).

The rate of energy generation depends on the number of atoms at the critical temperature, \( N_{\text{CRIT}} \). This in turn depends on the total mass of the star, \( M \), the average mass per critical atom, \( m \), and on the fraction \( F_{\text{CRIT}} \) of the mass \( M \) that is critical. Thus

\[ N_{\text{CRIT}} = \frac{F_{\text{CRIT}}M}{m_{\text{CRIT}}} \]  \hspace{1cm} (7)

Let \( P_{\text{ST}} \) be the total power output of a star. Then, assuming no accretion whatever, the lifetime of a star can be calculated as follows:

\[ L_{\text{ST}} = \frac{N_{\text{CRIT}}E_{\text{RAD}}}{P_{\text{ST}}} \text{ sec} \]  \hspace{1cm} (8)

For the sun,

\[ M = 2 \times 10^{30} \text{ kg} \]

\[ P_{\text{ST}} = 2.43 \times 10^{39} \text{ MeV/sec} \]

Taking thorium as representative of the critical elements,

\[ m = 2.988 \times 10^{-25} \text{ kg/atom} \]

Assuming various values of \( F_{\text{CRIT}} \), we can calculate the lifetime of a star with no accretion. The following table results.
According to the Reciprocal System, net accretion does occur over the life of a star, but there may be periods where there is a net loss. Since such a period may last as long as a billion years, I believe we are on good ground assuming that $F_{\text{CRIT}}$ is equal to .0001. At present we have no way of deducing theoretically the fraction of the mass of a star that is critical. Certainly, observation is no help; observation can only indicate the composition of the stellar atmosphere, not that of the central core.

**Rate of accretion**

The sun appears to be one-third along its way on the Herzsprung-Russell diagram. Since the sun has been estimated to be in existence for about 5 billion years, we can roughly assume that the average lifetime of a star is 15 billion years. According to the theory, a star slowly increases in temperature until the critical temperature of the iron group elements is reached, at which point the life of the star is terminated in a supernova explosion. From the equations presented in this paper, the critical temperature of iron is $3,091,400,000$ $^\circ$K above that of uranium. Thus the rate of change of temperature with time can be roughly expressed as follows:

$$\frac{dT}{dt} \approx \frac{\Delta T}{\Delta t} = \frac{3,091,400,000}{15 \times 10^9} = \frac{0.206}{\text{yr}}$$

(Even if $L$ were only $7.5 \times 10^9$ years, the increase in $T$ per year would be less than $0.5$ $^\circ$K).

Thus stars are for most of their lives very stable energy generators. From this we can conclude that the rate of accretion is just slightly greater than the rate of mass lost through burning. For calculating the rate of accretion we can assume that for the short term they are identical.

Let $R_{\text{ACC}}$ be the rate of accretion in kg/sec. Then

$$R_{\text{ACC}} = \frac{P_{ST}^{m_{\text{CRIT}}}}{E_{\text{RAD}}^{m_{\text{CRIT}}} F_{\text{CRIT}}}$$

Using previous values of $P_{ST}$, $E_{\text{RAD}}$, $m_{\text{CRIT}}$, and $F_{\text{CRIT}}$ equal to .0001.
\[ R_{\text{acc}} = 6.099 \times 10^{13} \frac{\text{kg}}{\text{sec}} \approx 1.925 \times 10^{21} \frac{\text{kg}}{\text{yr}} \]

This amounts to 0.000000096% of the mass of the star per year. It would take over 3108 years for the accretion to amount to the mass of the earth!

Clearly we cannot observe this small rate of accretion. Observation cannot tell us whether the mass of the sun is remaining constant or slowly increasing, as we believe, or whether the mass of the sun is slowly decreasing, as present theory suggests.

Conclusion

The current theory of stellar energy generation has been criticized elsewhere, and a summary of that criticism is presented in reference five. The basic differences between the new theory and the current one are as follows:

1) In the new theory, energy is generated by disintegration of heavy elements; in the current theory, energy is generated by fusion of light elements.

2) In the new theory, the temperature of the stellar core is of the order of \( 4.6 \times 10^{14} \text{ K} \); in current theory, it is \( 3 \times 10^{27} \text{ K} \) for the first phase, and \( 10^5 \) for later phases.

3) In the new theory, ordinary stellar energy generating processes do not give rise to neutrino emission, but in current theory they do. So far, no neutrinos have been found to emanate from the sun.

4) In the new theory, one method for energy generation serves all types of stars; current theory proposes that various stars have different energy schemes: proton-proton reaction; the CHO bi-cycle; helium burning; \((\gamma, \alpha)\) reaction of \( ^{12} \text{C}, ^{16} \text{O}, ^{20} \text{Ne} \) nuclei; e-process; r-process.

Thus, though observation (other than neutrino counts) cannot at present decide in favor of one theory over the other, Occam's Razor can: the new theory wins hands down.

References

4. For instance, a polynomial equation in \( Z \) has been worked out by computer by Frank V. Meyer: \[ E_1 = 78.6411 - 72.8213xZ + 33.6752xZ^2 + .801221xZ^3. \]
REFERENCE SYSTEMS
by
D. B. Larson
Portland, Oregon

As reported in the October 1977 issue of Reciprocity, I am now in the process of preparing the first volume of a revised edition of the book in which I introduced the Reciprocal System of theory, The Structure of the Physical Universe, a book which has been out of print for several years. As the successive chapters of the manuscript are completed, I have been circulating them for review and comment by a number of those members of the New Science Advocates with whom I have corresponded on the subject matter. One point that is already evident from the first comments that have been received is that it will be necessary to go into more detail in the discussion of the way in which our apprehension of the basic physical motions is affected by our choice of a reference system. I had already recognized this to the extent to including a chapter entitled "Reference Systems" in the draft of the revision that is now being circulated, but it seems clear from the comments that some aspects of the situation will require further clarification. I therefore intend to make some additions to the manuscript, but in the meantime a review of the principal points at issue may be of interest to the readers of Reciprocity.

The first point to be noted is that whether or not an object is in motion, and the amount of that motion, if any, depends on the reference system. An object which is stationary in one reference system is moving in any reference system that is in motion relative to the first system. Whether we see the motion of the object as a complex motion, a simple motion, or no motion at all depends on the reference system to which we relate it. One of the important findings of modern physics, confirmed by the Reciprocal System, is that there is no absolute reference system. No stationary reference system that we may select has any valid claim to superiority over another.

Another significant finding is that a reference system for motion necessarily includes a time datum as well as a space datum. For most ordinary purposes we refer changes in spatial position to the surface of the earth, but we realize that these motions would have some very different aspects if we adopted a different reference system, one based on the sun, for example. The development of the Reciprocal System of theory now shows that for a complete definition of a motion we must also specify position in time relative to some selected reference system. This is the fundamental fact that has heretofore gone unrecognized because it has been assumed ("without examination," as one prominent physicist puts it) that time always progresses uniformly at the rate indicated by a clock. On the basis of this assumption, the time registered by a standard clock is the same at all points in space. This makes it possible to represent motion in a coordinate system which provides only for variability in the three dimensions of space; that is, a spatial coordinate system. When we are dealing only with relatively low velocities, this is satisfactory, as the deviations from clock time at these velocities are negligible. At high velocities, on the other hand, the true rate of change of position in time is different from the rate indicated on a standard clock. In this case the conventional assumption that the standard clock registration is a correct measure of the change in time position is wrong, and it introduces an error.

The point that we now need to realize is that when we select some physical object, such as the earth, to define a spatial reference system, we are, by the same act, utilizing the position of the earth in time to define a temporal reference system. If an
object A is ejected from the earth with a speed $x$, this means that the change in the position of that object in space relative to the earth's location in space divided by the elapsed clock time plus or minus the change of position of that object in time relative to the earth's location in time is $x$. If a similar object B is ejected from Mars at speed $x$, the same statements apply to the motion of that object relative to the reference system defined by Mars. But if it is now desired to express the velocity of B in terms of the reference system defined by the earth, everyone realizes that the change in the relative spatial position of Mars and the earth must be taken into account. What was not realized before the development of the Reciprocal System is that there is also a change in the relative position of these two planets in time, and whenever the magnitude of this change is significant, it, too, must be taken into consideration. The true measure of the speed is the amount of change of position in space divided by the total time, including the amount of change of relative position in time. Clock time is a correct measure of the total time only at low relative speeds.

Much of the difficulty that some students of the theory are having in understanding the motion of photons of radiation could be avoided if it is recognized that although the photon motion is inherently scalar, once a direction has been imparted to it in the context of the spatial reference system, the photon moves in the same manner as any other object. The object A in the preceding paragraph could just as well be a photon as anything else. A photon emitted from the earth moves away FROM the earth just as any ejected material object will do, not from any kind of an absolute position that the earth was occupying at the time of emission. There is no absolute reference system by means of which such a position could be defined. When one unit of clock time has elapsed, the photon will be one unit of space distant from the earth, and since, in this case, clock time is the total time, the speed is $1/1 = 1$.

As in the preceding illustration which referred to the motion of material objects, if we want to express the motion of a photon emitted from Mars in terms of a reference system defined by the earth, the spatial distance traveled by the Mars photon in the reference system during one unit of clock time will be $l + a$, where $a$ is the effect of the relative motion of Mars and the earth. However, the distance component $a$ is traversed during a time $a$, which is separate and distinct from the one unit of time registered on the clock. The total time involved in the motion is there $l + a$, and the speed is $l/a/(l + a) = 1$. Thus the speed of the photon motion is independent of the reference system, but the spatial location is not.

No doubt some of the misunderstanding that I am now trying to correct is due to my use of the term "natural reference system." Even though I have continually emphasized that space and time do not constitute a setting or background for physical action, and that there is no absolute reference system, it has been widely assumed that this "natural reference system" is such a setting. As one correspondent puts it, "Whenever you talked about the progression of space...we instinctively assumed you were talking about the expansion of some background space...Objects not participating in such an expansion would emit photons by simply 'cutting them adrift' in the expansion." The term "natural reference system," as I am using it, has no such implications. A spatial reference system can be stationary, in which case the distances between its various parts remain the same as time progresses. Or it can be a moving system, in which case the distances between its various parts increase as time progresses. Inasmuch as each of the primitive undifferentiated motions that are the fundamental units of the physical universe involves one unit of space in association with one unit of time, the datum for physical activity -- the natural reference system -- is a system in which the various parts are moving outward (that is, distances are increasing) at a uniform unit speed. This is the natural system because it is the system in which any object, such as a photon, that has no capability of independent motion is stationary. It is essential to use the concept of such a reference
system in the development of theory, and a name must be assigned to it. The word "natural" is intended to express the fact that this system moving at unit speed is the system to which the universe actually conforms; that is, the only system with respect to which an object that cannot move is not represented as moving. While I realize that the term "natural reference system" is frequently misinterpreted, I do not believe that there is any alternate wording less open to misinterpretation that will express the true meaning.

The concept of an expanding system of reference is applicable only to scalar motion. It is unfamiliar because the existence of inherently scalar motion was not recognized prior to the development of the Reciprocal System, notwithstanding the fact that motions such as those of spots on an expanding balloon are obviously different in kind from ordinary vectorial motions. A reference system for scalar motion in a three-dimensional universe necessarily takes the form of a sphere. As the imputed direction of a scalar motion in such a universe is determined by chance, an object which has moved a scalar distance \( d \) from its point of origin during a certain interval will be found somewhere on the surface of a sphere of radius \( d \).

For the purpose of explaining the relation of such a reference system to the more familiar types, let us assume an object \( A \) to be motionless. A sphere centered at \( A \) then constitutes a stationary system of reference (magnitudes in which, of course, be expressed either in polar or rectangular coordinates). A sphere centered at object \( B \), which is not moving relative to \( A \), is part of the same reference system. A sphere centered at object \( C \), which is in motion relative to \( A \), is another reference system of the same kind. However, if the sphere centered at \( A \) is assumed to be expanding at rate \( x \), this constitutes a reference system of a different kind: a moving system. In the special case where the rate of expansion \( x \) is unity, one unit of space per unit of time, we have the natural moving system, the reference system to which the basic units of the universe actually conform. If an expanding sphere of this kind is centered at object \( B \) instead of object \( A \), it is another part of the natural system. However, both \( A \) and \( B \) can occupy positions in the same stationary reference system only if they are moving inward gravitationally. For all practical purposes, therefore, it can be considered that a separate system of reference is centered at \( B \). It is true that all points in reference system \( B \) are moving outward from \( A \), but this outward motion is counterbalanced by the inward gravitational motion of equal magnitude, so that the only effective motion of photons emitted from \( B \) is the motion outward from \( B \).

Generalizing the principle brought out in the foregoing paragraphs, we may say that scalar motion can be represented in a stationary three-dimensional system of reference only if reference points are defined. This limitation on our ability to represent motion in a fixed coordinate system may be annoying, but if we want to understand the physical universe we will have to take it as it is: we cannot force it to conform to what we think it ought to be, or to what we find convenient. The discovery that the physical universe transcends the limitations of our usual reference systems is one of the most significant of the results that have been obtained from the development of the Reciprocal System of theory. It is now clear that this universe cannot be forced into the mold that previous physical theories have prepared for it. There is no valid reason why physical action must be limited to those events and those phenomena that can be represented in the reference systems that the human race is capable of constructing, and the finding of the Reciprocal System is that it is not so limited. The inability to deal with scalar motion on the same basis as vectorial motion is only one of a number of instances where the universe refuses to stay within the boundaries of what is convenient for the human investigator.

Inability to represent change of position in time in a spatial reference system is another case of the same kind. I am continually receiving letters from individuals who
say that they need help because they are having difficulty in "drawing a diagram" to represent some motion in which change of position in time is involved, according to the theoretical findings. I cannot give any help in these cases, because motion in time cannot be represented in a spatial diagram. We are able to represent low-speed motion in such a diagram because no significant change of relative position in time is involved, but as soon as the speed is great enough to introduce such a change, the spatial diagram can no longer represent the motion accurately.

This is not something that is peculiar to the Reciprocal System. The reason for the difficulty at high speeds was unknown prior to the development of this new theoretical system, but its existence has long been recognized. It is a matter of fact that has to be faced regardless of what physical theory is accepted. In order to understand just what is involved, it should be realized that a diagram, or graphical representation, of a motion does not give us a true picture of that motion unless the spatial positions of the moving objects as shown in the reference system are consistent with the speeds. For instance, if the distance between A and B increases by x in time t, then the speed must be x/t; otherwise the motion is not correctly represented. But no spatial reference system can maintain this kind of consistency in representing high-speed motion.

The two-photon case that I have frequently discussed in my publications demonstrates this point. In this illustration, we assume two photons, A and B, emitted simultaneously from an object O in opposite directions. At the end of one unit of clock time, A and B are separated by two units of distance, and x/t = 2/1 = 2. But experiments show that the speed of A relative to B is only 1. Clearly, either the distance entering into the determination of the speed differs from that measured in the reference system, or the time differs from the uniform rate of progression that has to be assumed in order to make it possible to represent motion in a spatial coordinate system. In either case, the spatial reference system is not capable of representing the motion accurately. Current physical theory, based on Einstein assumptions, simply says that the coordinate positions have no meaning at high speeds. As expressed by Moller, "In accelerated systems of reference the spatial and temporal coordinates thus lose every physical significance; they simply represent a certain arbitrary, but unambiguous, numbering of the physical events."

Those who insist that we should be able to represent every motion by a spatial diagram are demanding something that has long been known to be impossible. Perhaps some day a device may be invented whereby change of position in three dimensions of space and change of position in three dimensions of time can be accurately represented in a diagram that can be comprehended by the human mind. In the meantime, we will simply have to recognize that some natural phenomena are not amenable to our cherished diagrammatic modes of representation, regardless of what kind of a theory we may use in our attempt to understand them. The only difference between the Reciprocal System and other theories, so far as this point is concerned, is that this new theoretical system has clearly identified the phenomena that the conventional systems of reference are unable to handle, including some phenomena such as scalar motion that have heretofore been overlooked, largely because of the tendency to insist that nature must conform to what the human theorists find convenient.

There is no good reason, however, why we should be disconcerted because nature refuses to make things easy for us. If we start with the basic units of motion and build the possible combinations of these units step by step in accordance with the rules specified in the fundamental postulates of the Reciprocal System, we define the physical universe, the universe of motion, in all of its detail. The universe as thus defined is rational, logical, and understandable. The fact that some of its magnitudes cannot be represented graphically in the manner to which scientists have been accustomed merely indicates that previous ideas as to the basic nature of these magnitudes are erroneous.