Non-Locality in the Reciprocal System

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Though quantum theory is phenomenologically successful, it fails to throw any light on the nature of the underlying physical reality. The Reciprocal System, true to its claim of a unified and general theory, not only covers the ground of the quantum theory, but also provides insight into the reality, basing on the new paradigm of motion as the sole constituent of the physical universe. Its most important finding is the existence of different domains of physical action, in which the rules of the game apparently differ. Larson resolves all the difficulties the conventional theory is facing, by the knowledge of the characteristics of these domains.

Thomas Kuhn, the renowned historian of science and its methodology, writing in *The Structure of Scientific Revolutions*[1], points out that as paradoxes and unsolved puzzles mount up in the science of an era, a state of crisis results. This initiates the development of new theories basing on a totally new paradigm. General acceptance of the new paradigm, however, is not automatic. Old theories die hard because emotional commitment, rather than pursuit of truth, invariably becomes the driving force. Continued endeavor to consider and study the new paradigm by open-minded students will gradually establish it in the scientific field. An interesting fact brought to light by Kuhn's study is that as more and more human effort gets spent in understanding the new paradigm, it becomes easier and easier for all people to understand it—as though entire mankind is one at deeper levels. Kuhn also points out that as more people accept the new theory, more evidence for it appears. Therefore, consideration of the recalcitrant problems in science—especially, in physics—and showing how the Reciprocal System of theory resolves them should be of interest to us. We shall consider a few of these:

Problem # 1: ***Unification of the four fundamental forces of nature.***
Scientists have not been successful in this enterprise of creating a grand unified theory; especially gravitation has not yielded to the unification efforts.

Problem # 2: ***The quantum measurement problem.***
In essence, this may be described as follows: Consider, for example, the two-slit electron interference experiment. While the intensity of the wave function represents the probability of finding a particle, the actual measurement reveals the arrival of a particle somewhere on the detector—say, at x_1—which is a discrete event. In a sequence of identical measurement situations, the location x_i where the i^{th} particle makes its appearance on the detector screen is totally random. But, the relative proportion (frequency) of the particle appearances at any location strictly follows the wave pattern predicted by quantum theory. How do the later particles 'know' the history of the earlier particles, and maintain the overall pattern? Even though individual particles come at different times, there seems to be some sort of connection through time existing among these!

Problem # 3: ***Instantaneous connectedness in space***.
Most accurate experimental verification of Bell's theorem has positively established that correlated quantum entities—as in the EPR experiment—maintain a strong nonlocal connection, however far they are separated in space. The surprising feature of this nonlocality is that it is immediate, not attenuated by distance and not mediated by any

1 Kuhn, Thomas S., *The Structure of Scientific Revolutions*, University of Chicago Press, Chicago, IL, 1976.

> medium. Even though quantum theory predicts the experimental results correctly, the inference of the existence of nonlocality is actually based on experimental facts—not on the quantum theory—plus Bell's Inequality theorem. Therefore, nonlocality has to be explained by any new theory that might encompass the quantum theory in the future. Nonlocality has been one of the most baffling features of quantum phenomena, defying all attempts to understand the nature of the reality underlying them.

Larson has discussed problem #1 in great length in some of his works[2,3,4,5,6] and developed the thesis sufficiently to establish that, in fact, the Reciprocal System is a unified and general theory. The application of the Reciprocal System to the study of the quantum domain, however, is urgently desiderate. Therefore, in the present discussion, we shall limit ourselves to the consideration of problem #2 and #3, only. Let us begin by briefly recapitulating the Reciprocal System of theory.

Conjugate Sectors of the Physical Universe

The two Fundamental Postulates of the Reciprocal System with which Larson[7] starts are:

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

II. The physical universe conforms to the relations of ordinary commutative mathematics, its primary magnitudes are absolute, and its geometry is Euclidean.

The motion which is the basic constituent of the physical universe is conceived by Larson as scalar motion, or speed, the ratio of space magnitude to time magnitude. All phenomena—radiation, matter, gravitation, electric charge, magnetism—come out as different possible modes of motion. Larson deduces the following:

> ***Corollary #1 (quantization)***: The two components of motion, namely space and time, are quantized;
>
> ***Corollary #2 (reciprocity)***: Space and time are reciprocally related to speed—an increase in space is tantamount to a decrease in time, and *vice versa*;
>
> ***Corollary #3 (symmetry)***: Both space and time have identical characteristics: time has three dimensions like space, and space, too, progresses like time does.

We find that the possible speeds in the physical universe fall into two natural ranges: from speeds zero to unity, and from unity to infinity. However, from the Reciprocal System we learn that speeds exceeding unity do not manifest as motion in space; instead, they manifest as *motion in time* (not the time travel of science fiction). Larson calls the domain of the physical universe in which the speeds range from zero to unity the ***material sector***, and that in which the speeds range from unity to infinity (or what comes to the same thing, the *inverse speeds* range from zero to unity) the ***cosmic sector***. By virtue of the symmetry, all the phenomena of the material sector, which is the sector we inhabit, are duplicated in the cosmic sector with the roles of space and time interchanged.

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2 Larson, Dewey B., *The Case Against the Nuclear Atom*, North Pacific Publishers, Portland, OR, 1963.
3 Larson, Dewey B., *Beyond Newton*, North Pacific Publishers, Portland, OR, 1964.
4 Larson, Dewey B., *Nothing But Motion*, North Pacific Publishers, Portland, OR, 1979.
5 Larson, Dewey B., *The Neglected Facts of Science*, North Pacific Publishers, Portland, OR, 1982.
6 Larson, Dewey B., *Basic Properties of Matter*, International Society of Unified Science, Salt Lake City, UT, 1988.
7 Larson, Dewey B., Nothing But Motion, *op. cit.*, p. 30.

Unit speed—which Larson identifies as the speed of light—is the boundary between the two sectors, and forms the background of the physical universe. Larson refers to this ever-present space-time progression at unit speed as the ***natural reference frame*** (which we shall refer to as the N-frame). An immediate consequence of the space-time progression is the observed recession of the galaxies (which is being mistakenly attributed to a hypothetical "big bang"). It also resolves the mystery of the propagation of radiation. Radiation is not propagated at all; the space unit, in which the photon is situated permanently, itself progresses.

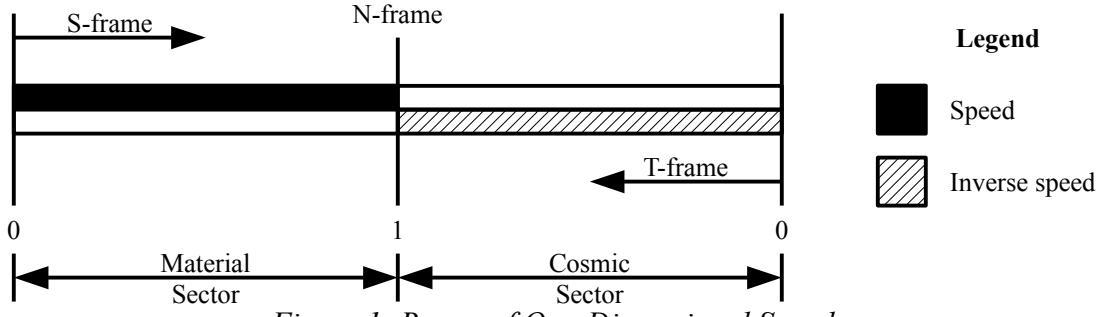

Figure 1: Range of One-Dimensional Speed

For reasons explained by Larson,[4] gravitation always acts in opposition to the ubiquitous progression of space-time. Since space-time progression acts outward in space (as well as outward in time), gravitation in the material sector acts *inward in space*, and gravitation in the cosmic sector (that is, cosmic gravitation) acts *inward in time*. So, to observers anchored to material aggregates, like we are, space appears stationary and three-dimensional, while time seems progressing one-dimensionally. The reference frame that is natural to us is the familiar stationary, three-dimensional spatial reference frame (which we shall refer to as the S-frame. See Figure 1).

In the cosmic sector, the result of cosmic gravitation acting *inward in time* is that the three dimensions of time and the one-dimensional progression of space stand out. The reference frame that is natural to the cosmic sector is the analogous three-dimensional, temporal reference frame (which we shall refer to as the T-frame).

In passing, we might recall that cosmic background radiation is the radiation emitted by cosmic stars of the cosmic sector, and cosmic rays are the cosmic matter ejected from the cosmic quasars. The uniformity and isotropy of both these items—which have no good explanation in conventional theory—can be seen to stem from the fact that they originate from *cosmic matter* which aggregates in three-dimensional time, but is randomly distributed in the S-frame of the material sector. The Gamma Ray Bursts too have their origin in the Cosmic Sector.

The Time Region

Imagine two material particles moving towards each other in space. By virtue of the quantization corollary, less than one natural unit of space cannot occur in physical interactions. Therefore, the particles cannot approach each other nearer than one effective unit of space in the S-frame. However, they can accomplish the equivalent of this, by virtue of the reciprocity corollary, by moving *outward in time*. Inside an effective unit of space, there cannot be motion in space; all motion has to be in time only. For this reason, Larson refers to the domain of physical action inside the effective unit of space as the ***time region***.

According to the Reciprocal System, the natural direction of the space-time progression is always away from unity. In the outer region (beyond unit space) away from unity is also away from zero, and hence the space-time progression acts outward (1/1). In the region inside unit space (the time region), however, away from unity is *toward* zero. Hence, the apparent direction of the space-time progression in the time region is inward (-1/1). Gravitation, as it always opposes the space-time progression, acts apparently outward in the time region. In the Reciprocal System, the physical *state*—not to be confused with the quantum mechanical state—is the result of reaching motion equilibrium between these two above motions in the time region, and pertains to the individual atom or molecule. It is not a group characteristic as in the conventional theory.

> ***Corollary #4 (physical state)***: The *solid state* is the result of reaching motion equilibrium in the time region in all three dimensions. The *liquid state* results when the motion in at least one dimension comes out of the time region, and the *gaseous state* when the motion is outside the time region in all three dimensions (that is, it is entirely in the S-frame).

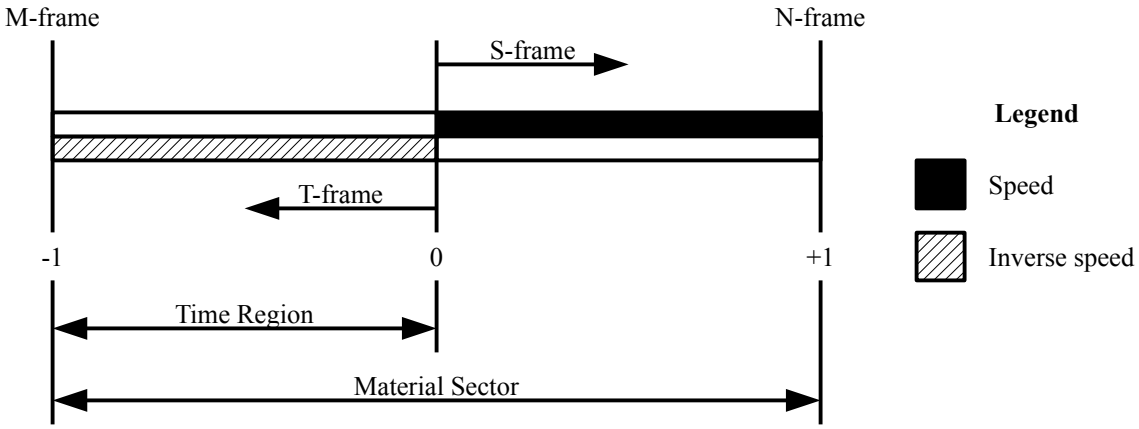

Figure 2: Time Region as a Sub-Region

We have now come to an important juncture. Outside unit space, since all motion is in space, the appropriate frame of reference is the conventional, three-dimensional stationary reference frame (the S-frame). However,

> ***Corollary #5 (frame-inversion)***: in the time region, since only motion in time can take place, the appropriate frame of reference that should be adopted is the three-dimensional temporal reference frame (the T-frame) (see Figure 2).

Summarizing: the physical universe comprises two sectors, the material and the cosmic sectors, with the applicable reference frames being the S-frame and the T-frame, respectively. In the material sector, there is a sub-region called the time region, whenever interactions take place in less than one (effective) space unit, with the applicable reference frame being the T-frame. (By symmetry, we have in the cosmic sector a sub-region, which we can call the ***space region***, with the applicable reference frame being the S-frame.) We have depicted these schematically in Figure 3.

Quantum Nonlocality

The crucial point that should now be realized is that as a quantum entity—like an electron or a proton—enters the time region, we should change the reference frame to reckon its motion(s) from the S-frame to the T-frame, for the reasons delineated above. We note that the origin (the zero-point) of the

conventional reference frame (the S-frame) is at zero speed in that frame. Similarly, the origin (the zero-point) of the temporal reference frame (the T-frame) is at zero inverse speed in that frame. But zero inverse speed is tantamount to infinite speed. Consequently,

> ***Corollary #6 (spatial nonlocality)***: the origin of the T-frame would be apparently at all places in our familiar S-frame and at the same time. In other words, it is *nonlocal in space*. Furthermore,
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> ***Corollary #7 (non-trajectory)***: the concept of a particle trajectory in the S-frame is not applicable from the point of view of the T-frame, for the obvious reason that the origin of the T-frame is 'everywhere' in the S-frame.

In an earlier paper, *Wave Mechanics in the Light of the Reciprocal System*,[8] we have shown that, by a consideration of the dynamical relationships,

> ***Corollary #8 (wave-particle equivalence)***: a particle localized in the S-frame is equivalent to a plane monochromatic wave from the point of view of a T-frame and vice versa.

We further pointed out that even though one should adopt the T-frame for the description of the interactions in the time region, there is no way to accomplish this since we—as creatures of the material sector—are unavoidably anchored to the S-frame. However, we can achieve the same result by adopting the expedient of shifting from the particle picture to the wave picture by virtue of Corollary #8. We can now see that to depict a quantum entity as both a particle and a wave is wrong. It is a particle, as viewed from the S-frame, and a wave as viewed from the T-frame (See Reference 8).

Before proceeding further, we have to note that there are two significant differences between the T-frame of the time region, and the T-frame of the cosmic sector. Referring to Figure 3, we would like to point out:

i. the speed and inverse speed ranges pertaining to the S-frame of the material sector and the T-frame of the cosmic sector respectively meet at unit magnitude;

ii. the speed and inverse speed ranges pertaining to the S-frame of the material sector and the T-frame of the time region respectively meet at zero magnitude. The mathematical fact that while the inverse of unity is unity, the inverse of zero is infinity introduces a profound difference here.

Firstly, the time region is the result of crossing the *unit space* boundary, while still in the material sector (S-frame), whereas the cosmic sector is the result of crossing the *unit speed* boundary in all the three dimensions of *motion*—mark it: three dimensions of *motion*, not three dimensions of *space*—and consequently moving out of the material sector, altogether. The motion germane to the cosmic sector is true motion in time and cannot be represented in the S-frame. On the other hand, the motion in time germane to the time region, does not manifest to us as motion in time per se, but, by virtue of the reciprocity corollary, shows up as *equivalent motion* in space (or as Larson puts it—motion in *equivalent space*, which is reciprocal space). This is, in fact, a general principle:

> ***Corollary #9 (equivalent space)***: so long as the net speed is on the material sector side of the speed range, the motion in time that might occur as a minor component of the overall speed configuration, acts as a modifier of the motion in space which is the major component. In other words, it manifests as motion in *equivalent space*, rather than motion in time.

Secondly, we have seen by Corollary #6 that as we switch from the S-frame to the T-frame on entering

8 Nehru, K.V.K., "The Wave Mechanics in the Light of the Reciprocal System," *Reciprocity*, XXII (2), Autumn, 1993, pp. 8-13.

the time region, the origin of the T-frame appears *everywhere* at *infinite speed*. Further, temporal dimensions are related to spatial dimensions only scalarly, that is, there is no geometrical (vectorial) relationship between temporal and spatial dimensions. Consequently, if we have a case of two distinct particles of the S-frame entering the time region, there is no reason why the three switched dimensions pertaining to one particle should hold any geometrical relationship to the three switched dimensions pertaining to the second particle. The origin (that is, the zero-point) of the two switched frames, however, is common since it is "everywhere" at "infinite speed." So,

> ***Corollary #10 (multiple dimensions)***: in the case of the frame-inversion (Corollary #5) of two interacting particles, *unless inhibited by special conditions*, we end up with six apparently different dimensions, three each of the two T-frames, respectively. Indeed, we require $3n$ dimensions to represent n particles.

We call this multi-dimensional manifold the *configuration space* to distinguish it from the conventional, three-dimensional space. We would like to emphasize here that this multiplicity of dimensions arises solely out of the scalar nature of the relation between temporal dimensions and spatial dimensions and not because the physical universe has a plethora of dimensions. Their occurrence is limited only to the sub-regions.

> ***Corollary #11 (temporal nonlocality)***: When the interaction eventually comes out from the time region back into the conventional frame, as at the measurement site, the reference frame has to be switched from the T-frame of the time region, back to the familiar S-frame. Like in the case of Corollary #6, this frame-switching entails the phenomenon of nonlocality. But this time, it is nonlocality *in time*, since the switching is T/S rather than S/T, and so the origin of the S-frame appears "everywhen" at "infinite inverse speed" from the point of view of the T-frame.

Quantum Interpretation Problem

The quantum theory has been successful and accurate in predicting the results of all the experiments related to quantum phenomena. But, it is a theory that does not provide any insight into the nature of the physical reality underlying these phenomena. It merely works like a recipe book for cookery. Therefore, scientists have subscribed to different views regarding reality—varying all the way from the "official" Copenhagen view, which denies the existence of any underlying reality, to the other extreme view of the "many worlds" interpretation of Everett. The question is yet unsettled. We shall show how the Reciprocal System, with its new paradigm, resolves the mystery and knits all the strange and seemingly weird features of the quantum world into one, logical whole.

Let us first note two quantum facts:

i. The attributes of the quantum entities fall into two types. The *static* attributes, like mass, spin and electric charge, are innate to the entity. The *dynamic* attributes, like position and momentum, seem to depend jointly on the entity and the reference frame of the measurement.

ii. Even in the case of dynamic attributes, so long as the quantum entity is not forced to go through tiny holes, or confine itself to tiny volumes, the entity appears to have a definite position and momentum—like a classical entity.

Both these above facts are in total consonance with the Reciprocal System finding that the non-classical behavior stems from the entry into the time region, which is a sub-region (tiny hole, tiny volume) of the *translational* motion (position, momentum or velocity).

Let us consider the familiar electron interference experiment. We have an electron source that shoots a coherent beam of electrons toward a phosphor screen target. Initially, we find a bright spot on the screen where the electrons hit. We then introduce a barrier into the beam provided with two small slits. If the width of the slit is of the order of the wavelength of the electrons in the beam, we observe the light and dark fringes of the interference pattern on the screen, instead of the single, bright spot.

There are four versions of quantum theory: the Matrix Mechanics (Heisenberg), the Wave Mechanics (Schrödinger), the Transformation Theory (Dirac) and the "sum-over-histories" approach (Feynman). All of these give the same final result, but Feynman's method gives us a better clue as to the nature of the wave function than, for example, solving Schrödinger's wave equation. Feynman makes two unusual assumptions, that:

(1) a single electron takes all possible paths and
(2) no path has a greater preference.

He implements these by assigning the same amplitude to each path. The history of each path, then, determines its phase for any location on the target screen. Feynman then arrives at the amplitude of the electron's wave function by summing up the wave amplitudes of all possible paths the electron can take to reach that particular location from its source.

Feynman's assumptions, that the single electron takes all possible paths at the same time and with equal probability are extremely outlandish. But the conclusions that we reach from the deductions of the Reciprocal System are exactly the same! Firstly, on entering the time region, the particle picture is to be replaced by the wave picture, due to the *frame inversion* and the *particle-wave equivalence* corollaries. Then, the simultaneous existence of all possible paths is the result of the *spatial nonlocality* corollary.

As the electron beam brightness is gradually reduced such that we have electron by electron hitting the target, rather than an ensemble all at one time, we fail to observe the interference pattern in real time. However, if we place a photographic plate adjacent to the phosphor screen and wait long enough for sufficient electrons to accrue, the pattern could once again be seen, despite the fact that the individual electrons that are arriving hit the screen at purely random locations. It appears as though it does not matter whether the electrons come at once as an ensemble, or they come at different times—the statistical wave pattern, observed in either case, is exactly the same. But, this is exactly what we should expect by the *temporal nonlocality* corollary! The same S-frame would appear to be present at all moments, nullifying the time delays between the individual electron events, as though merging them into a single ensemble.

The EPR Experiment

In certain atomic events, two correlated photons in what is called a *twin state* are emitted in opposite directions. In the particular experiment, the photons are polarization-correlated. In this state, either of the photons does not seem to have any definite polarization until measured, even though it is definite that they have mutually opposite polarization. Experiments show that, if we force one of them to take up a specific polarization direction at the first measurement site, the polarization of the twin invariably shows up (at the second measurement site) in the opposite direction, even if the two photons are so far separated in space as to be beyond the reach of the signal that could travel at light speed between them. The results apparently indicate that twin photons are causally connected even if they are beyond the "light cone."

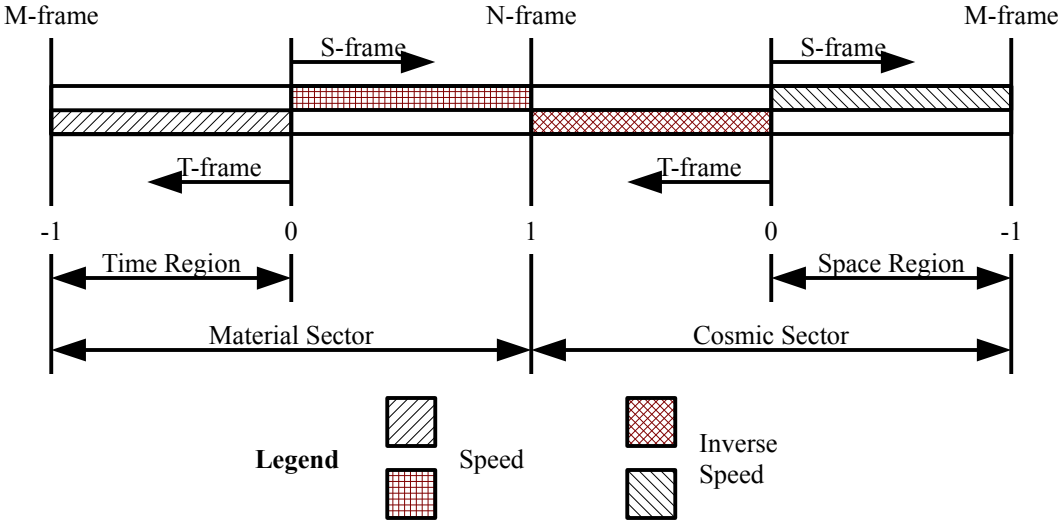

Figure 3: The One-Dimensional Speed Regions of the Universe

Discussing the primary motions in the physical universe, we have pointed out[9] that an intrinsically scalar quantity (motion) can manifest in the reference system as a pair of oppositely directed vector quantities, and not as a lone vector. A *bivector* acts as a true scalar: it does not have a specific direction before manifestation, and can assume any bidirection on manifestation. The twin state is a state of bi-polarization—*bi-momentum*, in the EPR original version—which can split into two oppositely directed polarizations in any specified direction.

Explaining the EPR phenomenon, Larson states in a communication:[10] "A photon occupies a position in the three-dimensional spatial reference system and also a position in the analogous three-dimensional temporal reference system. If two photons originate coincidentally in such a manner that they separate spatially, they may remain coincident in time; that is, in the same time unit or an adjacent unit. In this case, a change that takes place in one photon will cause an appropriate change in the photon to which it has a connection in time, just as it would if the two were connected in space.

"This idea that contact in time is subject to the same considerations as contact in space is not new to the students of the Reciprocal System of theory. It enters into a number of physical situations, particularly in the reverse application, where contacts in space are maintained unchanged when separation takes place in time. As an example...{see} *The Universe of Motion*,[11] in which I point out that this explains the containment of the high speed matter in the interiors of the giant galaxies."

In Figure 3, we have depicted the various speed domains of the physical universe which we derived from the theory. We now pursue the logical deduction further. We have seen that the space-time progression in the time region is inward in space (-1/1), whereas in the space region of the cosmic sector it is inward in time (1/-1). The time region begins at the zero inverse speed of the T-frame, and ends at -1 inverse speed of the M-frame. Similarly, the space region begins at zero speed of the S-frame and ends at -1 speed of the M-frame. At unit level, speed and inverse speed are effectively identical (-1/1 = 1/-1). Consequently, we get the complete picture if we unify the M-frame of the space region and the M-frame of the time region.

9 Nehru, K.V.K., "The Law of Conservation of Direction", *Reciprocity*, XVIII (3), Autumn, 1989, pp. 3-6.
10 Larson, Dewey B., Letter to David Halprin, Nov. 3, 1984.
11 Larson, Dewey B., *The Universe of Motion*, North Pacific Publishers, Portland, OR, 1984, p. 385.

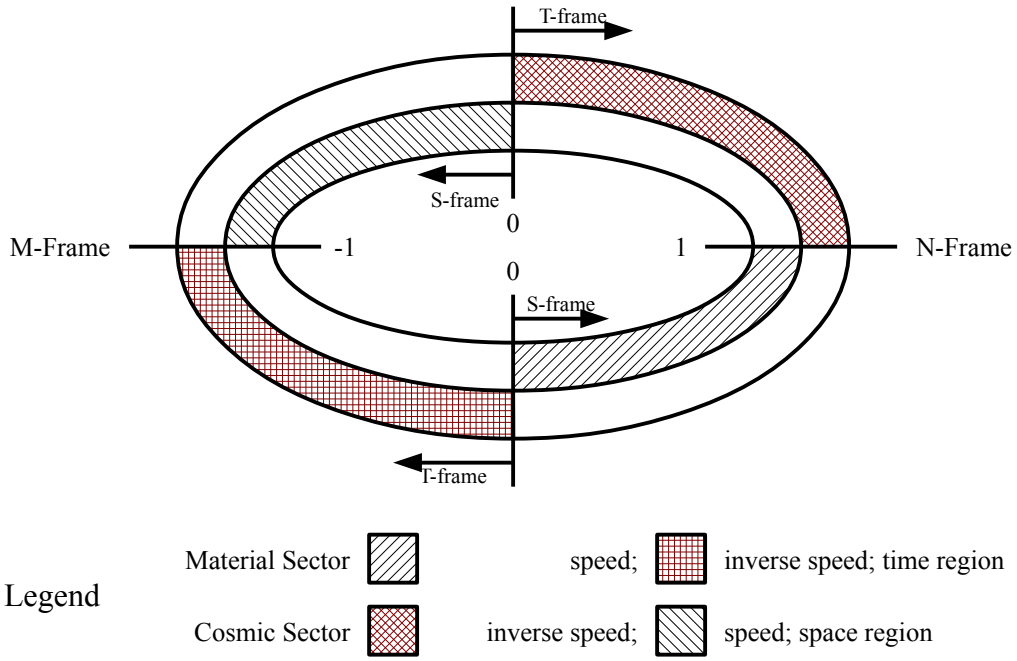

Figure 4: Unified Representation of the One-Dimensional Speed Regions

Since gravitation always acts in opposition to the space-time progression, it acts outward in the time region. It also turns out that since the space-time progression acts inward in time in the space region of the cosmic sector, cosmic gravitation in the space region acts outward, too.

> ***Corollary #12 (frame-merging)***: The final result is that the action of gravitation in the time region of the material sector, on one hand, and of cosmic gravitation in the space region of the cosmic sector on the other, are both outward.

Larson, in *Beyond Space and Time*[12] extends the application of his theory to the realms of life and consciousness. He notes that in the material sector, all structures spontaneously move from states of greater organization (or order) to states of lesser organization. In other words, the *available energy* goes on decreasing. But, in the case of *living units*, like the cells or higher life, the organization level is either maintained or increases, against all odds. It is still an enigma how life is possible at all, in the material universe, if we stick to purely mechanistic explanations.

Larson notes that while available energy goes on decreasing in the material sector, the inverse is true in the cosmic sector, namely, the available *inverse energy* decreases spontaneously. That is, the available energy increases! He, therefore, discovers that what we call a *living cell* comes into being when the purely material structural unit is connected to and governed by a *control unit* built of the cosmic structures. By Corollary #12 above, we can readily see how the linking of the cosmic unit with the material unit is possible, and how they can interact, since the nature of the governing force (motion) is identical in both of them. This control, of course, appears nonlocal.

12 Larson, Dewey B., *Beyond Space and Time*, Tucek and Tucek Book Publishers, Tucson, AZ, 1996.

Conclusion

The development of the Reciprocal System of theory finds space and time to be discrete, reciprocally related, and of symmetrical properties. It discovers another sector, the Cosmic Sector, of the physical universe wherein the applicable speeds range above the speed of light. The Cosmic Sector duplicates all the phenomena of our familiar Sector, but with the roles of space and time interchanged. The peculiar characteristics of the Cosmic Ray Primaries and the Cosmic Microwave Background emerge logically from the fact that they originate in the Cosmic Sector. Inside the quantum of space there is a sub-region, called the time region, with non-trivial space-time characteristics that directly lead to peculiar quantum phenomena. To a large extent, the development is in consonance with the procedures of quantum theory. In addition, it supplies what quantum theory fails to offer—a lucid understanding of the nature of quantum reality.

The Reciprocal System has rational explanations for perplexing quantum issues like:

- wave-particle duality
- spatial nonlocality
- temporal nonlocality
- breakdown of the trajectory concept
- multi-dimensional configuration space
- connection between the living and the non-living

In closing, we need to remind ourselves that the Reciprocal System is not just another new theory, but one that stems from an entirely new paradigm. The new paradigm, that motion is the sole and fundamental constituent of the physical universe, immediately repudiates the age-old practice of viewing space as a *container* for physical objects and time as a canvas on which the drama of the universe unfolds. Even though they appear so in the local environment, in reality they are the *contents* of the universe. The recognition that Reality need not be limited to what is representable in space and time opens the door for a truly scientific approach not only to the study of the physical universe, but also of living systems, para-psychological phenomena, and, indeed, consciousness itself.