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CRITICAL COMMENTS ON

"ON THE CONSTANCY OF THE SPEED OF LIGHT"

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1. INTRODUCTION

The new four-dimensional symmetry theory with universal time introduced by Hsu[1] was criticized in a recent article.[2] The new theory has been expounded more recently by Chiu, Hsu and Sherry.[3] In Reference 2, the authors claimed to have shown logical inconsistencies in the original work of Hsu. Moreover, they assert that any attempt to work with such a symmetry framework is wrong, by appealing to a derivation of the Lorentz transformation based on hypotheses which are different from those in Reference 1. As a result, they reject entirely the new symmetry theory.

We wish to comment on their article and to answer all their criticisms in this note. First we acknowledge that cerain of their criticisms of the new symmetry theory, as originally presented, are valid. This was noted independently by the present authors, and the corresponding changes have been made in the theory.[2],[4] However, other of their criticisms arise from misunderstanding the text of our work. Their further assertion that any such space-light transformation between inertial frames is wrong and must be dismissed, we also answer. This is quite a basic and subtle point that has to do with the original hypotheses upon which one builds one's theory. Their argument essentially compares the space-light transformation in our theory with the allowed transformations in a different theory. A scientific theory should be dismissed on the basis of contradiction with established experiment rather than contradiction with a theory built on different hypotheses. We shall now discuss in what sense the theories are different.

The authors in their earlier paper[(5)], show that they believe that the concepts of space and time should have special symmetry properties. This amounts to assuming that space $\underset{\sim}{r}$ and time t <u>must</u> <u>change</u>[1] under the transformation between inertial frames. They claim that "the relativity principle (for physical laws) together with the homogeneity and isotropy of space and the homogeneity of time" leads to an <u>unspecified</u> universal constant σ which is the coefficient of time in the

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[1]This is basically the same as Robertson's definition of interval as $d\tau^2 = dt^2 - d\underset{\sim}{r}^2/c^2$. As pointed out in Ref. (1), this very definition excludes the possibility of the universal time.

transformation and is the upper limit of speeds for physical objects. This has been correctly criticized in that the coefficient of time, σ, is implicitly assumed (in their derivation) to be unchanged under transformations.[6] Our work, however, relies in hindsight on the fact that the Lorentz transformations form a four-dimensional symmetry group of $\underset{\sim}{r}$ and σt. It is not space and time, as such, which possess the homogeneity and isotropy properties, but rather space and the product of σ and time. The point to note here is that the coefficient of time is assumed to be unchanged in special relativity and one derives uniquely the Lorentz transformation. But we hold that the four-dimensional symmetry scheme allows one to make a <u>different</u> assumption, thereby obtaining a different group structure.

In our approach, we begin with a four-dimensional framework which we identify as the three space dimensions and a fourth dimension x^o. The symmetry properties are then expressed for x,y,z and x^o. We yet have to specify, by an additional postulate, how x^o is to be identified. It is clear that the identification

$$x^o \equiv ct_R \quad (\text{or } \sigma t_R) \qquad (5)$$

where c is a universal constant and t_R is to be called the time gives us the special theory of relativity. However, we must recognize that this is a particular choice for x^o, and that other choices may also be made.[3] We make the alternative choice:

$$x^o \equiv bt_u$$

where t_u, which we call the time, or the universal time, is to be the same in all frames, and b is not to be universally constant. In general, the coefficient of the universal time is a function in the four-dimensional transformation. We note here, that as a result of this property the usual arguments to show that the coefficient of the time variable should be identical to the one-way speed of light do not follow through. The actual working out of the speed of light — and the different speeds which can in principle occur — is given in detail in our second paper.[3] We stress that one must be careful in interpreting the coefficient of time in such a theory which possesses a different concept of time. A theory consists of a scheme of equations, <u>together with</u> the rules for applying and <u>interpreting</u> the equations.[7]

The whole crux in understanding the new four-dimensional symmetry lies in the operational meaning of time. The universal time can be realized by the following clock system:[8]

Suppose there is only one set of clocks located everywhere in <u>any</u> <u>one</u> inertial frame, say the f frame. One can synchronize these clocks so that the speed of light is isotropic and has the constant value c in f. All observers in different frames use this set of clocks (which are everywhere in space) to record time, e.g., using the clock nearby an occurrence to record its time. (Of course, we assume that there are observers located everywhere in every frame.) In this way, all observers have a common universal time. It is really not necessary to duplicate identical set of clocks for each frame. With such a clock system, the one-way speed of light in a different frame f' will not be isotropic.

The major reason we feel such a formulation of four-dimensional theory is justified and worthwhile is that it involves a classical-like concept of time and, nevertheless, does not contradict previous experiments. Also, our theory possesses many features qualitatively the same as those of special relativity; for example, in each frame there is a limiting velocity in any direction—the limiting velocity is the 'speed of light in that direction'.

2. ANSWERS TO CRITICISM

We must first make some points related to the authors' introduction.[2] To begin with, our universal time must be distinguished from the Newtonian concept of time. While it is universal, it is not absolute in the Newtonian sense. (See Section 1 and Reference 3.) Secondly, we take issue with their describing x^o as "a product of... a relative speed of light c multiplied by a universal time t ". In fact this is at the root of many of their misunderstandings and criticisms. As explained in Section 1 and in our second paper,[3] the coefficient of the universal time is not to be confused with the speed of light. It is a function which specifies the frame of reference with respect to the particular universal time being used. Certain of its values are related to the different operational speeds of light (one-way or two-way, etc.). But one cannot require that all its values be physically identified in such a manner.

Let us now consider the difficulties with the new theory which are pointed out.[1] In their criticism (1), they claim that the 'Principle of Relativity' is not implemented in the work. From the discussion in Section 1 it should be evident that in terms of x,y,z and x^0, our theory is indistinguishable from the special theory of relativity. We interpret the 'Principle of Relativity' as the statement that the form of the laws of Physics should be the same in all inertial frames of reference. Clearly, since an inertial frame is labelled by x,y,z and x^0 (whatever the subsequent identification of x^0), we clearly have implemented it. What is not true is that physical constants, or rather those constants usually described as important 'physical constants', take the same numerical value in all inertial frames.

The main point of criticism (2) is valid. It was erroneous to discuss relative velocity between inertial frames with two distinct values. This point has been overcome in our second paper.(3) We might also note at this stage that the space light transformations relate the events

$$(ct,x,y,z) \text{ and } (c't,x',y',z').$$

It is not idle semantics to emphasize that all the coordinates of an event (or a point) should have the same dimensions, namely that of a length, and the same covariant transformation property, namely that of a 4-vector.

Criticism (3) arises from the misunderstanding alluded to in the first paragraph of this section. Since the coefficient of t is not of itself a speed of light [in expression (1) c' is not the speed of light at a point x',y',z', t !], we do not have the contradiction alluded to. We explain in detail in our second paper[3] that specification of operational constraints on x and t can lead to an identification of certain of the values of c' as speeds of light. The constraints are that x and t should be the space and time coordinates of a physical particle. The choices of x and t which give the problems from the authors' point of view[2] are thus seen not to be a problem for the speed of light.

Their statement, " Thus he (Hsu) interprets $\dot{x}$ as a particle velocity which is then required to satisfy $\dot{x} < c^2/v$ " in criticism (3) is wrong. There is simply no such requirement $\dot{x} < c^2/v$ for a particle velocity stated in Reference 1 . The particle velocity v is, of course, restricted by the mass formula $m(v) = m/(1-v^2/c^2)^{1/2}$ given by equation (21) in Reference 1 .

In answer to their criticism (4), we do not allow a physical speed to be greater than the speed of light in any frame. Our velocity transformation law is such that if the speed in one frame is less than the speed of light in the same direction, then it is also true in the primed frame. In this it is no different qualitatively from the special theory of relativity. To reemphasize, if a velocity is less than that of light in one frame, it is true in all frames. Hence a physical velocity is limited by the velocity of light.

The authors' final section is adequately answered in Section 1. With our understanding of reference frames it is clear that the space-light transformations are valid. The only quibble is the identification of time. We refer on this point to Reference (3).

3. CONCLUSION

In conclusion, we have answered each and every one of the criticisms raised by the authors. That is, we have shown that the new theory is not logically inconsistent — at least not for the reasons they express. It remains to be seen whether or not any inconsistency can occur. It seems to us, because of the approach explained in Section 4, that no internal inconsistency can occur.

It appears that the universal constancy of the speed of light is not essential to the understanding of natural phenomena or for the foundations of physics. What remains to be discussed, however, is whether or not the non-universality of the light speed and the universal time can be of benefit in physics. Will it reduce the number of fundamental universal constants of physics in the future?[2],(8) Will it simplify the setting up of clock systems?(3) Will it help the common people to understand the fundamental concepts of space and time in

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[2]Dirac believed that, in the physics of the future, the Planck constant, the electromagnetic coupling strength and the light speed cannot be all fundamental constants and that only two of them is fundamental.

physics? After all, the universal time[3](11) in the new theory is essentially the common-sense time. We feel that the time is ripe to discuss these questions.

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[3]Wheeler suggested that the concept of universal time could be defended from the viewpoint of the evolution of our universe as a whole.(10) This is in harmony with the clock system discussed in Section 1 and References (3) and (8).

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