Anisotropic propagation of light, correspondence principle and conformal invariance in special relativity

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The three issues, anisotropic propagation of light, correspondence principle and conformal invariance, are interwoven in this study. Anisotropy of the light propagation in special relativity is traditionally discussed in the context of conventionality of distant simultaneity [1]. It has been a much debated issue but, to date, a consensus exists that any value of Reichenbach's synchrony parameter ϵ between 0 and 1 is mathematically acceptable provided that the rest of the theory is adjusted in the appropriate way. Arguments against conventionalism are rather aimed to show that the value of $\epsilon = 1/2$ is privileged in some objective way.

In the present paper, we intend to shift the approach to the problem. We consider the situation when an observer is aware (believes, supposes) that anisotropy of space really exists. The anisotropy, in particular, should influence propagation of light and the observer tries to build the special theory of relativity consistent with the anisotropy in the light speed and the experimentally verified fact that the speed of light as measured over closed part is always c. How would he approach the problem of finding transformations between inertial frames? First, he must require, according to the principle of relativity, that the equation describing propagation of light had the same form in all inertial frames. However, he cannot draw from this the conclusion that the interval between two events is invariant with respect to the transformations since the symmetry arguments, on which standard proofs of special relativity rely, are not valid if anisotropy of space is present. So the observer must require the invariance of the equation of light propagation and satisfy a number of other physical requirements which are all covered by the requirement that the transformations between the frames form a group. From these two principles he would arrive at the transformations which, in general, do not leave the interval between two events invariant but modify it by a conformal factor. (The fact that conformal invariance comes into consideration in the theory using the invariance of the equation of light propagation is expected based on the results of [2] demonstrating invariance of the electrodynamic equations under the conformal group – although conformal transformations were traditionally interpreted as connecting systems of constant relative acceleration, see [3] for historical review.) In the transformations derived using a group property and invariance of the equation of anisotropic light propagation, the conformal factor remains undefined. Thus, the transformations contain two different constants, the parameter of anisotropy entering the equation of light propagation and the parameter defining the conformal factor, which are both measures of the size of the anisotropy. In this situation, the correspondence principle, according to which the transformations for the space coordinates should turn into the Galilean transformations in the limit of small velocities, is used to relate the conformal factor to the light speed anisotropy parameter. In the resulting transformations, the relations corresponding to measurable effects include the conformal factor, which cannot be equal to one for nonzero values of the anisotropy parameter. As distinct from the ϵ-Lorentz transformations (see, e.g., [4]), which are commonly treated as incorporating the effects due to the anisotropy of light propagation,.the relations of such an "anisotropic special relativity" *are not* reducible to their counterparts of the standard special relativity by a synchrony change.

Also another variant of the theory is presented which adheres to the view that there exists a preferred frame of reference related to the cosmic microwave background (CMB). Since it leads us to expect that the space anisotropy (if existed) might be due to motion with respect to the CMB, in this variant of the theory, we consider the group of transformations between inertial frames which keep the equation of the anisotropic light propagation invariant but allow a variation of the anisotropy parameter from frame to frame.

References

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