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Review of: "Can electromagnetic fields form tensors in a polarizable medium?"

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Potential competing interests: No potential competing interests to declare.

The paper aims to show that, whilst the electric and magnetic fields **E** and **B** transform as components of an antisymmetric rank-2 tensor in a vacuum, this is not the case for either the **E** and **B** or **D** and **H** field pairs in a polarisable medium with constant permittivity ϵ and permeability μ. In particular, it is demonstrated that the 4-component object (ϕ,A), where ϕ is the EM scalar potential and A is the EM vector potential, does not form a 4-vector in a polarisable medium.

The main proof of the paper given in Section 2 is sound and shows that the scalar and vector potentials do not transform as a 4-vector. Using the definition given for the fields, this then implies that the matrix Eq. (1) is not a tensor. The author states in the final paragraph of Section 2 that as the matrix F does not transform as a tensor, then neither does the matrix G given in Eq. (3). This is argued on the basis that their components differ only by a factor of either ϵ or μ. I do not believe that this argument is necessarily true. For instance, if we carry out tensor transformations on a 4-vector and an object based on this 4-vector, just with each of its terms modified by a constant factor, then the resulting transformation laws for the components of these objects are not necessarily consistent with each other. Could a clearer or more complete justification of this final part of the proof be given?

In the conclusions it is stated that there is **no way** in special relativity to calculate the electromagnetic fields in any case where there is a moving linearly polarizable medium. Can an explanation be given for why this is so? There are ways to calculate EM field transformations in special relativity without resorting to tensor transformations. For example, in “Introduction to Electrodynamics” by David J. Griffiths, pp. 525-535, the field transformations in a vacuum are determined by considering the motion of a solenoid and parallel plate capacitor. Is there any reason why these methods cannot be adopted for light in a polarisable medium?

The paper has a clear and useful result and I would suggest publication after the issues above have been addressed. In addition to these comments I have some minor suggestions that may help to improve the paper.

A citation should be given for the statement “It has sometimes been assumed that … in a linearly polarisable medium” within the abstract.

Details of the calculations ought to be explained more within the text rather than in footnotes: ϵ and μ should be defined and it should be specified that they are constant. It should be stated that the Einstein summation convention is employed, and that Maxwell’s equations are given in Gaussian units.

It may be beneficial to organise the background material demonstrating the tensor properties of F in a vacuum into one section, and the new material proving that F is not a tensor in a medium into another section. This would improve the overall clarity of the paper.