

Review of: "Quaternionic Bekenstein-Sanders Gauge Fields for TeVeS"

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Potential competing interests: No potential competing interests to declare.

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This paper concerns the gauge invariance of a consistency condition required by TeVeS theories, namely the gauge invariance of the constraint

$$B_\mu B^\mu = -1, \quad (1)$$

where B_μ is the Bekenstein-Sanders (BS) field central to the TeVeS theory of gravitation.

The approach is to express the theory and its gauge transformation in quaternionic form and find a class of gauge parameters for which the corresponding transform respects it.

The steps in the construction appeared to follow each other but I doubt that they prove what the author seeks to prove. My first concern is that the consistency condition only holds for a subset of possible gauge parameters, those for which, up to a local Lorentz transformation, the quaternionic part of their derivatives is orthogonal to the quaternionic part of the time component of the BS field. However, this implies a complementary subset for which condition (1) does not continue to hold. Does this reduce the overall symmetry of the TeVeS theory being considered? What is the physical significance of this reduction in gauge symmetry, if any, or of the gauge degrees of freedom of this complementary subset? The severity of this point is not clear but it needs to be acknowledged and discussed, even if it is innocuous or answered in the references.

My second concern is that while forms of the BS field which respect the constraint in eq (1) are shown to exist they are all generated from the trivial field $B_\mu = 0$ by gauge transforms, suggesting that the gauge field contains no dynamic degrees of freedom. Since it is responsible for the dynamics of a theory this is worthless unless it is describing some topological phenomena such as embedding, which is never indicated.

There is a large number of typos, the first of them in the title, which were primarily either spelling mistakes, typically "guage" instead of "gauge" though other words are also misspelt, or missing spaces. The typesetting of equations was exceptionally poor, an apparent combination of insufficient care and word processing software ill-suited to mathematical expressions. As a consequence I was often required to guess at the content

of equations. This made the paper very difficult to read. It needs to be rewritten with much greater care and preferably with a more suitable application, such as LaTeX. I am confused by eqn (2.1). Apart from the above-mentioned typesetting problems, shouldn't there be a left- and a right - gauge transformation? Only one transformation is shown here and it is neither.

Page 4 introduces $\tilde{g}_{\mu\nu}$ and $\hat{g}_{\mu\nu}$ without defining the former. I suspect they are the same thing.

Use of the Re (eqs (2.11, 2.13, 2.14, 2.16, 3.10)) and sinh (eq (3.6)) functions is unclear and parentheses should be used throughout as they were in eq (1.5). There were several instances of "gauge condition" instead of "gauge transform", with an equal sign being used when a right arrow was appropriate, including equations (2.6, 3.10, 1.1, 1.3).