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Teaching the Maxwell and Dirac Equations in the Same Algebra

GENE MCCLELLAN, None — The geometric algebra of 3-D Euclidean space is sufficient to write and solve both Maxwell's equations and the Dirac equation. The formulations are fully relativistic and covariant. In this approach both the Maxwell electromagnetic field and the Dirac electron field are expressed as linear combinations of the algebraic basis elements of the tangent space at a given point in space. It is noteworthy that there are eight independent basis elements of the geometric algebra of the tangent space just as there are eight independent quantities in the four complex components of the standard Dirac spinor. Expressing the Dirac field as a linear combination of basis elements of the tangent space greatly facilitates visualization of solutions of the Dirac equation and provides insight into the nature of spin up vs. spin down states and the distinction between electron and positron states. Geometric algebra is quite intuitive, needing only standard associative and distributive rules coupled with the anticommutation of two orthogonal vectors as in the traditional cross product. A good understanding of geometric algebra could be developed as part of a one-semester, advanced algebra course. It would then be straightforward to illustrate solutions of both the Maxwell and Dirac equations in an undergraduate physics course on wave equations.

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None

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