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Comment on a paper by Rindani and Sivakumar

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In a recent work Rindani and Sivakumar claim to have found a new spin-$\frac{3}{2}$ theory with novel properties. It is shown here that the system which they consider is equivalent to the conventional Rarita-Schwinger equation. Their approach therefore appears unlikely to succeed in eliminating any of the long-standing problems associated with the interacting spin-$\frac{3}{2}$ field.

It has been known for some time that interacting field theories of higher spin are plagued with inconsistencies. Perhaps the best known result in this subfield is the fact that it has not been found possible to quantize a pure spin-$\frac{3}{2}$ field coupled to an external electromagnetic field without the occurrence of anticommutators which violate the positivity of the metric.[1]

Recently, however, there has been a claim by Rindani and Sivakumar[2] (RS) that they have found a new theory which "is in direct contrast to all other half-integral theories ... which invariably have indefinite metric." The purpose of this Comment is twofold. First, the remark must be made that the preceding quote from the abstract of RS contains two errors. The case of spin $\frac{1}{2}$ must, first of all, be excluded from consideration, and, second, it is well known that an indefinite metric is only a problem in the interacting-field case. Since RS deals only with the noninteracting case, the claims of that work must be viewed as excessive and unwarranted.

The second purpose of the present work is to point out that the theory of RS is nothing more than a rewriting of the standard Rarita-Schwinger theory as developed, for example, in Ref. 1. In particular, the results of these two papers are entirely equivalent in the gauge chosen in RS. Although Ref. 1 is based upon Hermitian field variables, there is no significant difficulty in comparing it to the non-Hermitian operator formulation of RS. This claim of equivalence is thus easily verified by making the observation that the RS Lagrangian is the same as that of Ref. 1 if the vector-spinor ψ^μ of that work is replaced by $\psi^\mu-(i/m)\partial^\mu\phi$. This also renders transparent the gauge transformations

$$\psi^\mu(x)\to\psi^\mu(x)-\partial^\mu\epsilon(x),\quad \phi(x)\to\phi(x)+im\epsilon(x)\ ,$$

of which much is made in RS. At the point at which they are prepared to evaluate anticommutators they choose the gauge $\phi(x)=0$ and obtain results which are necessarily identical to those of Ref. 1. Although RS speculate that the interacting case will (because of the above gauge invariance) avoid metric breakdown, this conjecture does not seem credible since minimal coupling conflicts with this invariance. Furthermore, even an exact gauge invariance should not be expected to resolve this problem since the theorem of Ref. 1 concerning the necessity of secondary constraints remains valid even when a gauge invariance occurs. Also, it should be remarked that the claim of Ref. 2 that the problem of noncausal propagation has been solved in their Ref. 5 is not tenable since the proof requires the imposition of new and inadmissible constraints upon the system.

In summary, the problems of the interacting pure spin-$\frac{3}{2}$ field remain unaffected by the work of Ref. 2. These problems are highly nontrivial and it is by no means surprising that considerations of gauge invariance fail to resolve them.

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[1]K. Johnson and E. C. G. Sudarshan, Ann. Phys. (N.Y.) **13**, 126 (1961).

[2]S. D. Rindani and M. Sivakumar, Phys. Rev. D **37**, 3543 (1988).

