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Comment on "Wave functions for a Duffin–Kemmer–Petiau particle in a time-dependent potential" [J. Math. Phys. 48, 073515 (2007)]

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It is shown that the paper "Wave functions for a Duffin–Kemmer–Petiau particle in a time-dependent potential" by Merad and Bensaid [J. Math. Phys. **48**, 073515 (2007)] is not correct in using inadvertently a non-Hermitian Hamiltonian in a formalism that does require Hermitian Hamiltonians. © *2010 American Institute of Physics.* [doi:10.1063/1.3340896]

In a recent paper published in this journal, Merad and Bensaid[1] reported on the solution of the Duffin–Kemmer–Petiau (DKP) equation for spin-0 sector in a time-dependent linear scalar field using the Lewis–Riesenfeld (LR) invariant method.[2] The purpose of this comment is point to out that this alternative method is not applicable to the DPK theory.

The concept of invariance of a system, as introduced in Ref. 2, states that I is an invariant of the system ($\hbar = c = 1$) if

$$\frac{dI(t)}{dt} = \frac{1}{i}[I(t),H(t)] + \frac{\partial I(t)}{\partial t} = 0, \tag{1}$$

where i is the imaginary unit, and $I(t)$ and $H(t)$ (Hamiltonian of the system) are explicitly time-dependent operators. In this context, $I(t)$ and $H(t)$ should be Hermitians. On the other hand, the Hamiltonian form of the DKP particle with an electromagnetic interaction is written as

$$H_{\mathrm{DKP}} = i[\beta^k,\beta^0]D_k + \frac{ie}{2m}(\beta^\mu\beta^0\beta^\alpha + \beta^\mu g^{0\alpha})F_{\alpha\mu} + m\beta^0 - eA^0, \tag{2}$$

where $D_k = \partial_k + ieA_k$ and H_{DKP} satisfies an equation of Schrödinger type,

$$i\partial_t\psi = H_{\mathrm{DKP}}(t)\psi. \tag{3}$$

At this point, it is worthwhile to mention that H_{DKP} is not Hermitian,[3] as opposed to what was adverted in Ref. 4, since

$$(iF_{0i}\beta^i(\beta^0)^2)^\dagger = -(iF_{0i}\beta^i(\beta^0)^2) + iF_{0i}\beta^i. \tag{4}$$

This results in

$$H_{\mathrm{DKP}} - H^\dagger_{\mathrm{DKP}} = \frac{ie}{m}F_{0i}[\beta^i,(\beta^0)^2]. \tag{5}$$

Therefore, it is not correct to use the LR invariant method in the DKP theory. In fact, the LR invariant theory generalized in Ref. 5 for including non-Hermitian Hamiltonians in the context of the nonrelativistic quantum mechanics might be appropriate to deal with the DKP Hamiltonian.

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