NOTES

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As mentioned by Hamdan, Chamaa and Lopez-Bonilla [1] the Dirac's wave equation still has many features which have not been fully understood. One such feature concerning the beta matrix is discussed below:

In the Dirac free particle [2] Hamiltonian $H = c\boldsymbol{\alpha}.\boldsymbol{p} + \beta mc^2$, the first term is related purely with the motion of the particle while the second term describes the properties purely at rest. In the first term the linear momentum $\boldsymbol{p}$ is dotted with $\boldsymbol{\sigma}$ (because $\boldsymbol{\alpha} = \rho\boldsymbol{\sigma}$) which is essentially the inherent spin operator whose classical analog is rotatory angular momentum. A similar analogy should also hold for the second term *i.e.*, the mass m which is inertia for the linear motion should be multiplied by an inherent property representing the inertia for rotatory motion. Hence it may be proposed that β essentially measures moment of inertia I_o of the particle and the suggested relation between them could be $I_o = \beta(\hbar^2/mc^2)$. This is plausible because both β and I_o should be Hermitian operators with positive (negative) eigenvalues corresponding to particle (antiparticle). Starting with this idea the following speculations can be made. (i) Just as a conservation law holds for $\boldsymbol{L} + \boldsymbol{S}$ we expect the sum, $I_o + m\,x$ an appropriate operator, to be conserved. (ii) Since β commutes with $\boldsymbol{\sigma}$ hence I_o should be independent of the spinning of the particle and the expression $I_o\,\boldsymbol{\omega} = \hbar\,\boldsymbol{S}$ would define the classical analog of angular frequency.

REFERENCES

[1] Hamdan N., Chamaa A. and Lopez-Bonilla J., *On the relativistic concept of the Dirac's electron spin*, Lat. Am. J. Phys. Educ. **2**, 65-70 (2008).
[2] Leonard I. Schiff, *Quantum Mechanics* (McGraw-Hill, Tokyo, 1955) p. 323.