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Editorial | Open Access

On Neutrino in Deformed Relativity

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Editorial

Glinka [1] has considered the algebraic deformation of Special Relativity, which led to the equation

$$(\gamma^{\mu}\hat{p}\mu + mc^2 + \sqrt{\alpha}\frac{c}{\hbar}\ell\gamma^5\hat{p}^2)\psi = 0\,, \tag{1}$$

Which can be easily transformed into the pair of Dirac equations

$$(\gamma^{\mu}\hat{p}\mu - M\pm c^2)\psi = 0\,, \tag{2}$$

Where $M\pm$ are the emerging mass matrices, which can be written in the form

$$M\pm = \mu\overset{\pm}{R}\frac{1+\gamma^5}{2} + \mu\overset{\pm}{L}\frac{1-\gamma^5}{2}\,, \tag{3}$$

$$\mu\overset{\pm}{R} = -\frac{1}{c^2}\left(\frac{\varepsilon}{2}\pm\sqrt{\varepsilon^2-4\varepsilon mc^2-4E^2}\right), \tag{4}$$

$$\mu\overset{\pm}{L} = \frac{1}{c^2}\left(\frac{\varepsilon}{2}\pm\sqrt{\varepsilon^2-4\varepsilon mc^2-4E^2}\right), \tag{5}$$

Where $\mu\overset{\pm}{RL}$ reals and the energy parameter are $\varepsilon = \frac{\hbar c}{\sqrt{\alpha\ell}} = \frac{(\mu\overset{\pm}{L}-\mu\overset{\pm}{R})c^2}{1+\frac{8m}{\mu\overset{\pm}{L}+\mu\overset{\pm}{R}}} \geq 0$, gives the regularization bound $-\frac{\varepsilon}{2}\leq E\leq\frac{\varepsilon}{2}$, where as the squared-mass difference is $\Delta\mu^2_{LR} = (\mu^{\pm}_L)^2-(\mu^{\pm}_R)^2 = 32\pi\frac{\ell p}{\ell}M_p^2$.

Making use of the right- and left-handed chiral Weyl fields

$$\psi_R = \frac{1+\gamma^5}{2}\psi\,,\ \psi_L = \frac{1-\gamma^5}{2}\psi\,, \tag{6}$$

Where solves (2), one gets the system of two massive Weyl equations

$$(\gamma^{\mu}\hat{p}_{\mu}+\mu^{\pm}c^2)\begin{bmatrix}\psi^{\pm}_R\\ \psi^{\pm}_L\end{bmatrix} = 0\,,\ \ \mu^{\pm} = \begin{bmatrix}\mu^{\pm}_R & 0\\ 0 & \mu^{\pm}_L\end{bmatrix} \tag{7}$$

Which can be rewritten as the two-component Schrodinger equation

$$i\hbar\partial_0[\begin{pmatrix}\psi^{\pm}_R(x,t)\\ \psi^{\pm}_L(x,t)\end{pmatrix} = -\gamma^0\left(i\hbar c\gamma^i\partial_i + \begin{bmatrix}\mu^{\pm}_R c^2 & 0\\ 0 & \mu^{\pm}_L c^2\end{bmatrix}\right)\begin{pmatrix}\psi^{\pm}_R(x,t)\\ \psi^{\pm}_L(x,t)\end{pmatrix}. \tag{8}$$

For the initial momentum Eigen states $\psi^{\pm}_{R,L}(x,t_0)$

$$i\hbar\sigma^i\partial_i\psi^{\pm}_{R,L}(x,t_0) = p^{\pm 0}_{R,L}\psi^{\pm}_{R,L}(x,t_0)\,, \tag{9}$$

In the Dirac basis, one obtains

$$\begin{aligned}(\psi^{\pm}_R)^D(x,t) = \{[&\cos\left[\frac{t-t_0}{\hbar}E^D(p^{\pm0}_R)\right] -\\ &- i\mu^D_{\pm}c^2\frac{\sin\left[\frac{t-t_0}{\hbar}E^D(p^{\pm0}_R)\right]}{E^D(p^{\pm0}_R)}]\exp\left\{-\frac{i}{\hbar}p^{\pm0}_R(x-x_0)_i\sigma^i\right\}(\psi^{\pm}_R)^D(x_0,t_0) -\\ &- ip^{\pm0}_L c\frac{\sin\left[\frac{t-t_0}{\hbar}E^D(p^{\pm0}_L)\right]}{E^D(p^{\pm0}_L)}\exp\left\{-\frac{i}{\hbar}p^{\pm0}_L(x-x_0)_i\sigma^i\right\}(\psi^{\pm}_L)^D(x_0,t_0)\}\times\\ &\times\exp\left\{-i\frac{(\mu^{\pm}_R-\mu^{\pm}_L)c^2}{2\hbar}(t-t_0)\right\},\end{aligned} \tag{10}$$

And

$$\begin{aligned}(\psi^{\pm}_L)^D(x,t) = \{[&\cos\left[\frac{t-t_0}{\hbar}E^D(p^{\pm0}_L)\right] +\\ &+ i\mu^D_{\pm}c^2\frac{\sin\left[\frac{t-t_0}{\hbar}E^D(p^{\pm0}_L)\right]}{E^D(p^{\pm0}_L)}]\exp\left\{-\frac{i}{\hbar}p^{\pm0}_L(x-x_0)_i\sigma^i\right\}(\psi^{\pm}_L)^D(x_0,t_0) -\\ &- ip^{\pm0}_R c\frac{\sin\left[\frac{t-t_0}{\hbar}E^D(p^{\pm0}_R)\right]}{E^D(p^{\pm0}_R)}\exp\left\{-\frac{i}{\hbar}p^{\pm0}_R(x-x_0)_i\sigma^i\right\}(\psi^{\pm}_R)^D(x_0,t_0)\}\times\\ &\times\exp\left\{-i\frac{(\mu^{\pm}_R-\mu^{\pm}_L)c^2}{2\hbar}(t-t_0)\right\},\end{aligned} \tag{11}$$

Where $E^D\left(p^{\pm0}_R\right) = c^2\sqrt{\left(\frac{\mu^{\pm}_R+\mu^{\pm}_L}{2}\right)^2+\left(\frac{p^{\pm0}_R}{c}\right)^2}$, while in the Weyl basis

$$\begin{aligned}(\psi^{\pm}_R)^W(x,t) = \{&\cos\left[\frac{t-t_0}{\hbar}E^W(p^{\pm0}_R)\right] -\\ &-ip^{\pm0}_R c\frac{\sin\left[\frac{t-t_0}{\hbar}E^W(p^{\pm0}_R)\right]}{E^W(p^{\pm0}_R)}\}\exp\left\{-\frac{i}{\hbar}p^{\pm0}_R(x-x_0)_i\sigma^i\right\}(\psi^{\pm}_R)^W(x_0,t_0) +\\ &+ i\mu^{\pm}_L c^2\frac{\sin\left[\frac{t-t_0}{\hbar}E^W(p^{\pm0}_L)\right]}{E^W(p^{\pm0}_L)}\exp\left\{-\frac{i}{\hbar}p^{\pm0}_L(x-x_0)_i\sigma^i\right\}(\psi^{\pm}_L)^W(x_0,t_0)\,,\end{aligned} \tag{12}$$

And

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$$(\psi_L^{\pm})^W(x,t)=\{\cos[\frac{t-t_0}{\hbar}E^W(p_L^{\pm 0})]- +ip_L^{\pm 0}c\frac{\sin\left[\frac{t-t_0}{\hbar}E^W(p_L^{\pm 0})\right]}{E^W(p_L^{\pm 0})}\}\exp\{-\frac{i}{\hbar}p_L^{\pm 0}(x-x_0)_i\sigma^i\}(\psi_L^{\pm})^W(x_0,t_0)+ +i\mu_R^{\pm}c^2\frac{\sin\left[\frac{t-t_0}{\hbar}E^W(p_R^{\pm 0})\right]}{E^W(p_R^{\pm 0})}\exp\{-\frac{i}{\hbar}p_R^{\pm 0}(x-x_0)_i\sigma^i\}(\psi_R^{\pm})^W(x_0,t_0)\,. \quad (13)$$

Where $E^W\left(p_R^{\pm 0}\right)\equiv c^2\sqrt{\left(\sqrt{\mu_R^{\pm}\mu_L^{\pm}}\right)^2+\left(\frac{p_R^{\pm 0}}{c}\right)^2}$.

In this manner, throughout the massive Weyl equation and manifestly unitary two-component Schrodinger equations, the model of Deformed Relativity leads to a massive normalizable neutrino states.

References

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