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Duffin Kemmer Petiau Oscillator under the Effect of an External Magnetic Field in Non-Commutative Space

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Introduction

- Recently, there has been a lot of interest in studying quantum mechanics in noncommutative space, for example in Refs[1-2]. String theory and M-theory arguments were used to explain low-energy D-brans excitations in the presence of EM-like fields[3-6].
- The goal of this study is to find the (DKPO) of spins 0 and 1 in a noncommutative space (NCDKPO).Mirza et al.[7] have already addressed this issue in the context of noncommutative Klein–Gordon oscillators (NCKGO) and Dirac oscillators (NCDO). They demonstrated that in a noncommutative space, the Klein– Gordon and Dirac oscillators behave similarly to the Landau problem in a commutative space.

The DKP equation in NC space written as

$$\left[c\beta\cdot\left(\boldsymbol{p}-\frac{eB}{c}\times\left(\boldsymbol{r}+\frac{\boldsymbol{\theta}\times\boldsymbol{p}}{2\hbar}\right)-im\omega\eta^0\left(\boldsymbol{r}+\frac{\boldsymbol{\theta}\times\boldsymbol{p}}{2\hbar}\right)\right)+mc^2\right]\widetilde{\Psi}=E\beta^0\widetilde{\Psi}$$

➢Scalar Case

The energy spectrum

$$\boldsymbol{E_{n,l}}=\pm\boldsymbol{mc}^2\left[\mathbf{1}-\frac{\mathbf{2}\boldsymbol{\omega}\hbar}{\boldsymbol{mc}^{\mathbf{2}}}\left(\mathbf{1}+\frac{\boldsymbol{m}\widetilde{\boldsymbol{\omega}}\boldsymbol{\theta}}{\hbar}\right)+\frac{\mathbf{2}\hbar}{\boldsymbol{mc}^{\mathbf{2}}}(\mathbf{2}\boldsymbol{n}+\boldsymbol{l}\right.$$

➢Vector case

In this case, the wave function of spin 1 is a vector with ten components [2],then we decoupling the system

$$(\boldsymbol{E}^2 - \boldsymbol{m}^2\boldsymbol{c}^4)\boldsymbol{A} = \boldsymbol{c}^2[(\boldsymbol{p}^+ \cdot \boldsymbol{p}^-)\boldsymbol{A} - (\boldsymbol{p}^+ \times \boldsymbol{p}^-) \times \boldsymbol{A}] - \frac{1}{\boldsymbol{m}^2}\boldsymbol{p}^+\left[\boldsymbol{p}^- \cdot [\boldsymbol{p}^+ \times (\boldsymbol{p}^- \times \boldsymbol{A})]\right]$$

By a direct calculation for the first two terms of Eq(6),therefore we use the non relativistic limit.

The final expression of the non-relativistic energy spectrum is

$$\boldsymbol{E}_{n,l} = \omega\hbar\left(1 + \frac{m\tilde{\omega}\theta}{\hbar}\right) + \hbar(2n + l + 1)\sqrt{((\tilde{\omega} \pm \omega)^2 \pm 2\tilde{\omega}\omega)\left(1 + \frac{m\theta}{\hbar}(\tilde{\omega} \pm 2\omega) + \frac{m^2\theta^2}{4\hbar^2}((\tilde{\omega} \pm \omega)^2 \pm 6\tilde{\omega}\omega)\right)} - \left(l\hbar \pm \frac{\hbar}{m}\right)\left((\tilde{\omega} \pm 2\omega) + \frac{m\theta}{2\hbar}((\tilde{\omega} \pm \omega)^2 \pm 2\tilde{\omega}\omega)\right)$$

Conclusion

In this paper, we used non-commutative geometry to investigate the DKP harmonic oscillator equations in two-dimensional space under an external uniform magnetic field. Using the confluente hyper-geometric, we were able to obtain analytical expressions for bound state energy and wave function for spin 0. Otherwise, because finding an exact solution to the problem in the vector case was nearly impossible, we limited our research to the non-relativistic limit of this case.