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On the Non Relativistic Modelling of the Generalized Symmetric Woods-Saxon Potential Energy with Snyder-De Sitter Algebra

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ABSTRACT

In this talk, we present how to formulate an interaction in a non-relativistic equation by employing the Snyder-de Sitter algebra. As a particular example, we employ the generalized symmetric Woods-Saxon potential energy.

1. INTRODUCTION

In the field of high energy physics, we observe that there is increasing interest in theoretical research to investigate the deformation of ordinary quantum mechanics. The idea underlying this interest is that measurements have a fundamental scale. This limit is approximately on the Planck scale. This limit is approximately on the Planck scale and results with a nonzero value of uncertainty. This result is known as the generalized uncertainty principle and frequently employed in noncommutative geometry, string theory, and black hole physics [1].

The Schrödinger equation is a non-relativistic equation that examines the dynamics of low-speed particles in ordinary quantum mechanics. The physical processes are taken into account with the potential energy term which is coupled to the kinetic term of the Hamilton operator. One of the potential energy function among many others is known as the Woods-Saxon potential energy [2]. In 1954 Roger D. Woods and David S. Saxon employed this function in the optic model to describe the nuclear interaction forces. Later, Satchler modified the Woods-Saxon potential energy with extra terms that describe the surface interactions. This form of the potential energy is named as the generalized symmetric Woods-Saxon potential energy [3].

In this talk, we discuss the formulation of the Schrödinger equation with generalized symmetric Woods-Saxon potential energy with Snyder-de Sitter algebra.

2. THE MODEL

In one spatial dimension, the time independent Schrödinger equation is given by

$$\hat{H}\psi(x) = E\psi(x) \tag{1}$$

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where the Hamilton operator is

$$\hat{H} = \frac{\hat{P}\hat{P}}{2\,m} + U(x) \tag{2}$$

Here, the generalized symmetric Woods-Saxon potential energy is defined

$$U_{GSWS} = \theta(-x)\left(-\frac{V_0}{1+e^{-a(x+L)}} + \frac{W_0 e^{-a(x+L)}}{\left(1+e^{-a(x+L)}\right)^2}\right) + \theta(x)\left(-\frac{V_0}{1+e^{a(x-L)}} + \frac{W_0 e^{a(x-L)}}{\left(1+e^{a(x-L)}\right)^2}\right) \tag{3}$$

Note that θ(±x) represents the Heaviside step function, whereas V_0, a, and L are the potential parameters that adjust the depth, slope and the effective distance of the potential energy function.

In this study we use the deformation of the the Synder-de Sitter algebra [4]. In this case, the usual Heisenberg commutation relation changes to the following form

$$[\hat{X}, \hat{P}] = i\hbar\left(1 + \alpha\hat{X}\hat{X} + \beta\hat{P}\hat{P} + \sqrt{\alpha\beta}\left(\hat{X}\hat{P} + \hat{P}\hat{X}\right)\right) \tag{4}$$

In position representation the noncommutative operators are modifed as follows

$$\hat{X} = (1-\rho)\frac{x}{\sqrt{1-\alpha x^2}} - i\hbar\sqrt{\frac{\beta}{\alpha}}\sqrt{1-\alpha x^2}\,\frac{d}{dx} \tag{5}$$

$$\hat{P} = -i\hbar\sqrt{1-\alpha x^2}\,\frac{d}{dx} + \rho\sqrt{\frac{\alpha}{\beta}}\frac{x}{\sqrt{1-\alpha x^2}} \tag{6}$$

Note that, ρ is an arbitrary parameter [5]. Then, the uncertainity relation modifies to the form of

$$\Delta X\,\Delta P \geq \frac{1}{2}\left(1 + \gamma + \sqrt{\alpha}(\Delta X)^2 + \sqrt{\beta}(\Delta P)^2 - 2\sqrt{\alpha\beta}\Delta X\Delta P\right) \tag{7}$$

where

$$\gamma = \sqrt{\alpha} < \hat{X} > + \sqrt{\beta} < \hat{P} > \tag{8}$$

The latter uncertainty relation gives rise to new uncertainty values in position and momentum uncertainty as follows [6]:

$$\Delta X \;\geq \sqrt{\frac{\beta(1+\gamma)}{1+2\sqrt{\alpha\beta}}} \tag{9}$$

$$\Delta P \;\geq \sqrt{\frac{\alpha(1+\gamma)}{1+2\sqrt{\alpha\beta}}} \tag{10}$$

CONCLUSIONS

In this talk, we briefly discuss how the ordinary quantum mechanics is modified under the Snyder-de Sitter algebra in means of non-relativistic point of view. The solution of the generalized symmetric Woods-Saxon potential can be obtained by solving the second order differential equation.

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