Thermal Properties of the Klein-Gordon Oscillator in Deformed Space

M'hamed HADJ MOUSSA

Department of physics, Faculty of Sciences, Saad Dahlab-Blida-1 University, BP 270, 09000, Blida

ABSTRACT

Different methods used Heisenberg's generalized uncertainty principle (GUP) and the extended uncertainty principle (EUP) that allows the generalization of physical quantities in relativistic or non-relativistic quantum mechanics. In this work, we have treated the problem of the thermal physical properties of the Klein Gordon oscillator in the deformed space within the framework of the minimum length with the generalized uncertainty principle (GUP). This study provides a precise vision of the behavior of particles in the deformed space depending on whether the temperature value is high or low.

Keywords: Minimum length, Klein Gordon Oscillator.

INTRODUCTION

In recent years, there is a studies carried out in the chosen space such the phase space, non-commutative space and deformed space ... etc, to improve physical properties. In this work we interest in the deformed space by using the minimum length with a deformation parameter Beta (β) [1-2] . Where the uncertainty of Heisenberg is generalized. Our objective is to calculate the physical properties for understanding the behavior of the particles in high or low temperature.

THEORETICAL STUDY

The one dimensional Klein–Gordon oscillator equation is given by "we put ℏ= c = 1"

$$[(\hat{p} + im\omega\hat{x})(\hat{p} - im\omega\hat{x}) + m^2 - (E - q\varepsilon\hat{x})^2]\psi(p) = 0$$

Where ε is the intensity of electrical field and q is the electrical charge. Our algebra is defined as [1-2]:

$$\hat{x} = i(1 + Bp^2)\frac{d}{dp}$$

$$\hat{p} = p$$

Where $\hat{x}$ is The position coordinates operator and $\hat{p}$ is the operator of the momentum coordinates

RESULTS AND DISCUSSION

After to calculate the spectrum energy in the case ε=0 we calculate the partition function z as follows:

$$Z = \sum_{n=0}^{\infty} exp\left\{-\left(\frac{E_n - E_0}{K_B T}\right)\right\}$$

We use the Taylor-Maclaurin developments, and by the necessary approximations, we obtain

$$Z \approx \frac{1}{2} - \frac{1}{2}\sqrt{\frac{\pi}{\beta\omega^2\mu^4}}\left(\left(\frac{T}{T_0}\right)^{\frac{1}{2}} + U\left(\frac{T_0}{T}\right)^{\frac{1}{2}} + \frac{U^2}{2}\left(\frac{T_0}{T}\right)^{\frac{3}{2}} + \cdots\right)$$

DOI: 10.21467/abstracts.122 ISBN: 978-81-954993-3-5

Where

$$\lim_{\varepsilon \to 0} \mu = 1 - \frac{1}{\beta m \omega}$$

and

$$U = \frac{\beta \omega^2 \mu^2}{2} + \frac{1}{2\beta m^2}$$

Now, we can deduce the other thermal properties free energy F, mean energy U, specific heat C and entropy S by the following relations.

$$F = -K_B T \ln Z, \qquad U = K_B T^2 \frac{\partial \ln Z}{\partial T},$$

$$C = \frac{\partial U}{\partial T} \quad and \;\; S = -\frac{\partial F}{\partial T}$$

CONCLUSION

The analysis of the physical properties of thermodynamics, allows seeing these thermal properties depend on beta deformation parameter as well as the variation according to the high or low temperature within the formulas calculated analytically and their graphical representation.

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ISBN: 978-81-954993-3-5

Series: AIJR Abstracts

DOI: 10.21467/abstracts.122