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Equations of State and Applications in Astrophysics: Impact of Changed Dispersion Relations on Free Fermi Gas

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Introduction

The study of Fermi gas equations of state with applications to compact objects takes into account deformed dispersion relations. The formulation of our model makes use of a variety of different options for deformed energy relations. We consider a relativistic star with a straightforward internal structure as a first test. Depending on the functions used, the obtained mass-radius diagrams suggest that deformed Fermi gas has a positive effect. We also discuss how realistic equations of state that take into account interactions between nucleons can be solved [1].

In spite of the numerous endeavors made lately, joining gravity with quantum mechanics stays perhaps of the best test in hypothetical material science. By relying on alterations to special relativity that can result in a deformation of the Lorentz symmetry, it is possible to maintain the relativity principle at this scale. The dispersion relation is altered by doubly/Deformed special relativity (DSR) theories, which take into account an invariant energy scale in addition to the invariant velocity scale. These modifications have applications in astronomical and cosmological observations that are very intriguing. A portion of these perceptions, remembering limit irregularities for astronomy information, have been dissected in thinking about distortions of exceptional relativity scattering connection [1].

The ability to incorporate effects from multiple theoretical and observational motivations into a single scheme is an important feature of DSR. For example, a bright cut-of anticipated by certain outcomes in the writing of dark openings material science can be considered in a scattering connection. Additionally, the thermodynamics of such a compact object brought about by these modifications may cause the geometrical position of the horizon to be uncertain. In addition, the effects of Planck scale generalized uncertainty principles on the location of a black hole's horizon can be interpreted as being caused by a horizonless compact object, whose phenomenological possibilities were recently investigate in. The formalism we employ here takes into account a universally applicable expression for particle energy. By assuming theoretical and observational deformations, we create expressions for the energy density and other relevant quantities. The low limit energy is the focus of this investigation, which yields the usual relations predicted by special relativity [2].

Description

As a result, the aforementioned effects point to the possibility of having an impact on other compact objects like relativistic stars, where the high matter density has a significant impact on the kinetic terms of the equation of state. A free Fermi gas model in which DSR effects alter the relationship between energy density and pressure inside the star can be used to accomplish this. In this context, recent research has examined the connection between Lorentz invariance and Fermi gases and other thermodynamic systems. We examine the structure of a straightforward Neutron Star (NS) model and present a Fermi gas that has been altered as a result of the DSR. The modified equation of state (EoS)'s effects on the mass-radius diagram are the primary focus of this study [2].

The general relativity theory is based on Einstein's equations. The hydrostatic equilibrium of isotropic, homogeneous, spherically symmetric, static (no rotation) objects can be described by solving these field equations. This is a reasonable approximation for the so-called compact astrophysical objects, such as white dwarfs, magnetars, neutron stars, and others. The nuclear fusion of the chemical elements contained within these objects comes to an end at the same time as their birth. The equilibrium between the nuclear degeneracy pressure and the gravitational field ensures the conditions of equilibrium. The physics of these things involves two steps, which agree: first, using nuclear physics to build an EoS; second, the application of the TOV equations, relativistic hydrostatic equilibrium equations derived from general relativity [3].

Various nuclear interactions, such as Skyrme, Gogny, and relativistic mean field (RMF), are frequently investigated in NS research while preserving the kinetic contribution to energy as a Fermi gas. The EoS, which describes a Fermi gas without interaction, is the subject of our current investigation into how the DSR affects it. We investigate the impacts of this change on the perceptible properties of a straightforward NS model created by free neutrons as it were. This work is the first step toward a more realistic description of a NS within the context of DSR, in addition to comprehending the modification on the kinetic Fermi energy, which is the primary objective of the present study [3].

NSs are the final stage of massive star collapse, as previously mentioned. During the dynamical course of breakdown of these stars, atomic cycles happen, for example, electron catch, which make the heavenly matter more extravagant in neutrons, in such an extent that the proton part of the star is near or then again less and most particles are neutrons. In this way, in a decent estimate, a NS is created just by neutrons. Protons and electrons in beta-equilibrium with neutrons are also known to exist in the NS, and the inner core of the star may contain more exotic states like hyperons or quark matter. A single species is the easiest case because the focus of this study is on the effects of deformed fermionic kinematics on changes. As a result, we continue our investigation by applying the DSR equations to neutron-only matter [4].

If we can demonstrate, using the modified dispersion relation's dependence on momentum and mass, that there is a decrease in energy for a given mass and momentum in first order perturbation. The interaction with the quantum spacetime degrees of freedom, as phenomenologically represented by the dispersion relation, could theoretically be interpreted as reducing a portion of the particle's energy from a physical standpoint. On the other hand, a characteristic of this relationship is that its group velocity, does not follow the energy reduction, or at least reduces much less when analyzing higher order corrections, in first order Planck scale perturbation (corrections start at second order). As a result, each pressure value, one assigns a smaller energy value in response. As a result, when we compare the pressure to the energy density, we observe stiffness in the EoS, confirming that there is in fact a relative increase in group velocity in relation to the particle's energy [5].

Conclusion

We use a simplified version of NS that are made up of neutrons that don't interact with each other because NS are mostly made up of neutrons. We note that a nuclear interaction and the presence of other particles, such as protons and electrons in beta-equilibrium with neutrons, are required in a more realistic model of NS in nature. The effect of modified special relativity on a free Fermi gas, which is a change in the stiffness of the EoS in comparison to that of special relativity, is clearly demonstrated by the simplified model presented in this work.

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In order to comprehend the effect of DSR in more realistic models, it will be interesting to extend our method to the study of an EoS with modified relation dispersion, including nuclear interaction applied to TOV. Implementing DSR at a finite temperature, which is essential if one is interested in studying EoS for supernovae, is another enhancement for future work.

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Conflict of Interest

None.

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