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Zero Point Energy as Sea of Energy

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Abstract

The concept of zero-point-energy (ZPE), it's relation to Heisenberg's uncertainty principle, and being an essential concept in quantum field theory is brought out in this manuscript.

The existence of ZPE of vacuum is now recognized in several disciplines of physics, such as astrophysics and Quantum Electrodynamics; and that this energy can be converted into different classical types of energy in the laboratory, especially the electrical or mechanical energy. Zero-point-energy converters can be developed for everyday life use. However, a lot more has to be done to convert ZPE into a free sea of energy.

Keywords: Quantum restlessness; Sea of energy; Conversion

Introduction

As the temperature is reduced such that the temperature T→0K, and if necessary external pressure is applied, the assembly gets crystallized and such an assembly is then called a quantum crystal system. A quantum crystallinesystem is said to be an intrinsically restless system with large-zero-point energy (ZPE). Thus, it is said that the ZPE is due to quantum fluctuations of the system in the crystalline state.

Zero-point-energy is defined as the expectation value of the Hamiltonian of the system in the ground state. In quantum field theory, the vacuum state is the quantum state with the lowest possible energy. It contains no physical particles and this is the energy of the ground state. It is also called the ZPE. The ZPE is the greatest gift the quantum world can ever give us. It is a byproduct of the fact that the subatomic particles do not really behave like single particles, but like waves constantly flirtting between different energy states. This means that even the seemingly empty vacuum space is actually a rolling sea of virtual particles fluctuating in and out of existence and all those fluctuations require energy.

In physics, we still do not have a full theoretical model for understanding zero- point energy (Z P E). The discrepancy between Theoretical and observed vacuum energy is a source of major contention. Physicists John Wheeler and Richard Feynman calculated the zero – point radiation of the vacuum and showed that its magnitude is much bigger than the nuclear energy so much so that the one tea cup had enough energy so as to coil all the world's oceans. [1]. Whereas according to Einstein's Theory of general relativity any such energy would gravitate and the experimental evidence from both the expansion of the universe, dark energy and the Casimir effect show that any such energy has to be exceptionally weak. A generally acceptable proposal that attempts to address this issue is to say that the fermion field has a negative Z P E, while the boson field has positive Z P E, and these energies somehow cancel each other out. Such a situation could be realized only if super symmetry were an exact symmetry of nature. Even the Large Hardron Collider (LHC) at CERN has not so far found any evidence to support super symmetry. However, if supper symmetry is valid at all, it is at best a broken symmetry, only true at very high energies and there is no theory to show that zero – point cancellations occur in the low energy universe. This discrepancy is known as the Cosmological constant problem and it is one of the greatest unsolved mysteries in Physics.

In German language, ZPE is called Nullpunktsenergie [2]. The terms zero – point radiation or ground state energy can be used interchangeably. When referring to specific vaccum field, the term zero –point – field (ZPF) is used, as for instance in QED (quantum electrodynamics) Vacuum which deals with electromagnetic interactions between photons, electrons and vacuum, or the QCD (Quantum Chromodynamics, that deals with colour charge interactions between quarks, gluons and the Vacuum). A vacuum need not be viewed as an empty space but a combination of all zero – point fields. In quantum field theory (QFT), this combination of fields is called the Vacuum State, and the energy associated with the Vacuum State (ZPE) is called Vacuum energy, and the average energy value is called The Vacuum expectation value (VEV), also called its condensate.

In classical mechanics, all particles are assumed to have potential energy and Kinetic energy. Whereas the temperature and its magnitude depend on the intensity of random motion of the particle caused by Kinetic energy (known as Brownian Motion). As the temperature is reduced to 0K, all motion can be assumed to cease and the particles may be at complete rest. However, particles still remain in some random motion due to the uncertainty principle of quantum mechanics, and this corresponds to ZPE that is always finite.

According to uncertainty principle no object can ever have definite values of position and momentum simultaneously. The total energy of a quantum mechanical system, both potential and kinetic, is described by its Hamiltonian. The system may be a harmonic oscillator described by a wave function, and it may fluctuate between various energy states. In fact, all quantum mechanical systems undergo fluctuations even in the ground state, and this is a consequence of their wave – like nature. According to uncertainty principle, every quantum mechanical system must have fluctuating zero – point –energy (ZPE) greater than the minimum of its classical potential well.

This leads to motion even at absolute zero, and that is why liquid helium (${}^{4}_{2}$He) does not freeze under atmospheric pressure even if the temperature $T \to 0K$, and this is due to Z P E. [3] .Some recent remarks about Z P E can be studied in a recent article[4].

Theory

Quantum systems constantly fluctuate intheir lowest energy states due to the Heisenberg's Uncertainty principle. A vacuum state is reallynot empty, even if there are no particles; there is still energy and fields. The vacuum energy is simply the energy that fields have when they are in the vacuum (no particles) state.

To understand how ZPE can differ from system to system, the ZPE of the harmonic oscillator consisting of a hypothetical particle of mass m=2.33x10-26kg =2.33x10-23g, and the force constant=155N/m is calculated knowing that the Planck's constanth=6.626x10-27erg sec, and then

$$ZPE = \varepsilon_0 = \frac{1}{2}\frac{h}{2\pi}\sqrt{\frac{k}{m}} \cong 430 \times 10^{-16}\, erg.$$

For the same value of k, if the particle is He-4, then m=6.64x10-24g, and $\varepsilon_0 = 2500 \times 10^{-16} erg$ as far as we know there is no direct measurement value of k for solid He. However, a relation exists [5] between the Debye temperature $\theta_D$and k. i.e

$$\theta_D = \frac{2.95\hbar}{k}\sqrt{\frac{k}{m}} \qquad (1)$$

Where k is Boltzmann constant=1.36x10-16erg/degree, substituting the value of k from equation. (1) into expression for ε_0 we get ZPE as;

$$\varepsilon_0 = \frac{k}{5.90} \approx 0.23 \times 10^{-16} erg \qquad (2)$$

This value is comparatively small and depends on the value of k.

Quantum restlessness and uncertainty principle: Since a quantum crystalline system is intrinsically restless, it has a large zero-point-energy (ZPE). Because of the large ZPE in solid He-4, the observed mean position of atom is quite different from the minimum pointof classical potential energy surface. The observed nearest neighbour distance, calculated from experimental data at melting pressure near absolute zero temperature $(T \to 0K)$,is about 30% longer than the distance at which interaction potential is a minimum [6,7].

In fact, one can deduce [5] from the known experimental data that the root mean square distance of a wave packet representing an atom is about 30% of the nearest neighbor distance. Thus if is the nearest neighbor distance (interparticle distance), then the fluctuation;

$$\Delta X = \frac{30}{100} X_O \qquad (3)$$

The feature that makes solid ${}^{4}_{2}He$ unique is the dominant role played by the zero – point motion such that the contribution made by the ZPE represents approximately 98% of the total energy of the crystal [8]. A number of important consequences of this large Zero – Point – Motion are that liquid helium does not solidify under its own vapors pressure and even if $T \to OK$. To produce solid He, external pressure of 25baror more is required. Another important feature is that in the solid state, the crystal is much larger than could be expected from the inter-atomic potential determined by the physical properties of the gas. Because of the role played by the ZPE, these crystals are often called 'Quantum crystals' and their properties have been described, within the framework of the quantum theory of the many – body problem [9]. It should be emphasized that not all of the solids formed by helium are 'quantum crystals', solid helium at small molar volume (i.e. under very high pressure) is, to a large extent, a normal classical solid. Thus experiments must be done in the quantum region of the phase diagram of ${}^{4}_{2}He$ to verify the same.

Conversion of Zero – Point – Energy into High – Energy Photons:-The most important problem now is how to extract the zero-point-energy and convert it into a macroscopic form so that it can be utilized. It seems that it is possible in reality and there is an example of this. It is known that two hydrogen atoms, each in the ground state, are acted upon by the attractive Van der Waals force which brings them togetheruntil activation of covalent forces, from a large distance. In this process the sum of the kinetic energy of atoms and the zero point energy of photons is conserved. Then the emission of the energy of 4.72eV, which is the binding energy of , by H_2photons transfers the system to the ground state as a result, zero-point photon energy is reduced by 1eV, and the vacuum energy is emitted (energy from nothing) [20-24]. Another process is the mechanism of conversion of zero-point electromagnetic energy into high – energy photons up to a few M eV[25]. This mechanism is based on anomalous electron photon states. There were experiments done on high – current glow discharge in various gases resulting in strongly collimated X-ray laser bursts[26]. These experiments point to the conversion of zero-point-energy into high – energy photons[25]. The mysterious phenomena of X-ray laser bursts emitted from the solid disconnected for a long time from an external energy source point to some new process of energy conversion, which in this case is interpreted as the conversion of zero-point energy into high-energy photons[27]. X-ray laser bursts of keV energy are emitted from a metal where long-living states result in population inversion. These states are associated with narrow, 10^{-11}cm, potential well created by the local reduction of zero-point electromagnetic energy. In contrast to analogous Van der Waals potential well, leading to attraction of two hydrogen atoms, the depth of the anomalous well is of the order of 1 MeV. The states in that well have a longer lifetime.This results in population inversion and the subsequent generation of laser radiation that is emitted as X-rays. The X-ray emission, occurring in transitions to lower levels, is due to the conversion of zero-point electromagnetic energy.

ZPE trapped at crystalline state: Consider that at the crystalline site, the atoms (or neutron on the side of neutron star) are in a square well potential of depth V and width b. To get a bound state of the (Neutron pair- pair Neutron), the minimum depth V0m turns out to be;

$$V_{0m} = \frac{\pi^2 \hbar^2}{4mb^2} = \frac{1.026 \times 10^{-28}}{b^2} MeV \qquad (7)$$

If we choose b=2fm (fm=10-13cm), then$V_{0m} \cong 25MeV$, which is quite large. Thus at each site huge amount of energy is stored in the crystalline state. If the number of sites is of the order of $N \cong 10^{23}$, a large amount of energy stands trapped at the sites in the crystalline state and this is ZPE.

Results and Discussion

The above sections emphatically describe that there are various systems in which ZPE, is stored and in some cases, experiments have been done to release ZPE, for instance, the conversion of zero-point energy into high-energy photons.

In microscopic physics, the ZPE is an essential part of Quantum theory. By introducing vacuum – polarization into Quantum Electrodynamics, Richard Feynman brought in the concept of ZPE of the vacuum. Vacuum polarization describes the fact that spontaneous virtual pair productionof particle – antiparticle – pairs occur in empty space, which annihilates after a definite amount of time and distance. But these particles have a real mass (both particles and anti – particles, like electrons and protons, resulting from electron –positron pair production). This shows that they contain energy according to the mass – energy relation $(E = MC^2)$. Although this antimatter and matter annihilates soon after its creation within the range of Heisenberg's uncertainty principle, it contains energy in the empty space (there is no other source), from which these particles and anti-particles are created. Hence the empty space contains energy, which now-a-days we call zero-point-energy (ZPE). It is said that this energy from the empty space has to disappear within Heisenberg's uncertainty relation$(\Delta E \Delta t = \hbar)$because of the law of conservation of energy. Hence this energy exists as zero-point-energy of vacuum; how it can be utilized is a subject matter for investigation in future. This is an open field and immense potential exists for future research. For instance, can we design a compact, portable electricity generator that does not consume fossil fuel but produces useful amount of electrical power that is longer lasting, preferable on the order of years. ZPE fuel cells may be an alternative in future.

Conclusion

Equation (5) shows that the value of ZPE, $\in_0$, changes asΔXvaries, and the value of ΔX depends on the value of X_o, as is evident from Eq (3). The new energy discovered by T. Henry Moray is renewable energy throughout space, and hence energy shortage is a fraud according to Moray.

The importance of ZPE is sufficiently described in a statement 'Why Atoms Don't Collapse. It is stated that there is a dynamic equilibrium in which the zero-point-energy (ZPE) stabilizes the electron in a set ground state orbit. Thus there is a sea of energy, called ZPE. The X-ray emission, occurring in transitions to lower levels, is due to the conversion of zero-point electromagnetic energy.

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