Dynamics of the Vacuum

Harold White, Jerry Vera, Paul Bailey, Paul March, Tim Lawrence, Andre Sylvester, David Brady

NASA Johnson Space Center, 2101 NASA Parkway, MC EP4, Houston, TX 77054, USA

Abstract

This paper will discuss the current viewpoint of the vacuum state, and explore the idea of a "natural" vacuum as opposed to immutable, non-degradable vacuum. This concept will be explored for all primary quantum numbers to show consistency with observation. A comparison with the Casimir force per unit area will be made, and an explicit function for the spatial variation of the vacuum density around the atomic nucleus will be derived. This explicit function will be numerically modeled using the industry multi-physics tool, COMSOL®, and the eigenfrequency for the n=1 to n=7 states will be found and compared to expectation.

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Introduction

The current viewpoint of the quantum vacuum, or vacuum state, is that it is an immutable, non-degradable state for all observers and systems. The concept of the vacuum state is typically introduced as a ground state of a harmonic oscillator, so the viewpoint that it is immutable is reasonable. How can the vacuum, being the ground state of a harmonic oscillator, be anything other than "zero" for all observers? What if, however, the vacuum could be posited to be a plenum that can be shown to be degradable, and has the capability to support particle-vacuum or particle-particle interactions that allow lower energy, ground states? It is known from experimental observation that the vacuum can exhibit characteristics that can best be associated with a degraded vacuum in the form of the Casimir force [1][2]. The Casimir force arises as a result of a geometric conducting boundary in the form of two plates being placed in close proximity to one another such that the geometry of the cavity can preclude the ability for certain wavelengths of light from being present in one direction. The integral of the spectrum of vacuum fluctuation frequencies in between the two plates has a different starting point that the integral of the spectrum of vacuum fluctuation frequencies outside of the plates. The difference between these two integrals is what is considered to be responsible for the manifestation of this force. In this scenario, the vacuum state between the two plates is considered to be at a lower state than the vacuum state on the outside of the plates, or the toy vacuum model harmonic oscillator is at a lower state than "zero." Perhaps this is illustrating a deficiency in the way in which the vacuum state is described and understood. The Casimir force strongly indicates that the vacuum is degradable, however, this concept is at odds with the idea of a zero state of a harmonic oscillator, so perhaps a prudent path to explore is to consider the concept that the quantum vacuum is a bit more "natural" than a toy harmonic oscillator and can have spatial and temporal variations, and to see if this mutable quantum vacuum identifies with any inconsistencies with observation.