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Selenu's Phase as a Quantum Phase

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Abstract

The phase of a system of quantum states is calculated as the Selenu's phase, else as the circulation of the quantum momentum linear connection. The latter is shown to be the quantum potential generated by translations of the quantum states of the linear momentum of the quantum wave fields.

Keywords

Electron Field, Cosmology, Theoretical Physics

1. Introduction

In this article, a main attempt onto the determination of the geometric quantum phase of a quantum field is reported as a counterpart to the well-known Berry's phase. Different from previous works [1] [2], the geometric phase is calculated as the momentum linear connection circulation in space while not considering anymore the parametrical variation of the quantum phase either along a loop. The results highlight the importance of the phenomenon of matter generation discovered by the author [3], which is considered a change in the number of states of a physical system due to the circulation of linear momentum. This circulation occurs as events flow throughout the quantum system, generating a new potential. This is further demonstrated by showing how the quantum phase can become a detectable physical variable in the laboratory, as evidenced by the prototype experiment of the Aharonov-Bohm effect [4]-[8]. The next section will be a reported demonstration of the theorem considering also conclusions reported at the end of the article.

2. Quantum Phase

In this section, it is reported the demonstration of the Selenu's phase as being the geometric quantum phase acquired by a quantum system of wave field functions during a transformation, determining in space a potential function, whose gradients represent the linear momentum field. It will be reviewed also the demonstration of a quantum wave field having to it associated with a quantum phase acquired during the phase transformation itself, not recurring anymore to the concept of a parametric change [1] [2] of the quantal states of the quantum matter system. Recognized as wave fields being dependent on space coordinates, making change the quantum states themselves, has been neglected by the phenomenon, a possible intrinsic dependence of the transformation to be on a loop, varying on a parametrical cycle, allowing to determine the new concept of a quantum potential. Avoiding then classical quantum field theories of the wave field linear momentum transported by the quantum states, it will be shown, in the case of a quantum linear momentum circulation the latter to be written in terms of the generalization of the Poincarè invariant called in this article Selenu's phase [8]. The acquired quantum phase then is demonstrated to be strictly related to the action of potential operators of quantum matter, the former determining the translational properties of the wave fields. Translational properties in fact allow to represent an operatorial potential $U = \mathrm{e}^{\mathbf{r}\cdot\nabla}$ being itself considered the cause of the motion of the system in its quantum states as its infinitesimal variations determine the linear momentum field. It is then understood the infinitesimal motion of the system being the change of wave field amplitudes as having a local phase dependence by spatial coordinates as an infinitesimal local translation of the system, determined point by point, and related to the observation on each point of a quantum body state $\left|\Psi(\mathbf{r}_0)\right\rangle$. The latter is also considered not normalized on each point along during the transformation on a manner that can be evaluated the Selenu's phase as also reported in Ref. [8] defined as the changing of the number of quantum states of a physical field, here reported as it follows:

$$\Phi = \mathbf{Im}\ln \mathrm{e}^{i\int_0^{[p]}\langle\nabla\rangle\cdot\mathrm{d}\mathbf{r}} \tag{1}$$

where the integral of the differential form can be calculated from an initial point 0 to a final point p on the $\mathbf{r}_0$ space coordinate as the infinite sum:

$$\Phi = \lim_{\mathrm{d}\mathbf{r}\to 0}\mathbf{Im}\ln \mathrm{e}^{i\sum_j \langle j|\nabla|j\rangle\cdot\Delta\mathbf{r}_j} \tag{2}$$

Evaluated the logaritmic function of the quantum integral at its first order expansion on the exponential function and considered here as an infinite product of exponentials:

$$\Phi = \lim_{\mathrm{d}\mathbf{r}\to 0}\mathbf{Im}\sum_j \ln\left[1+\left\langle j\middle|\nabla\middle|j\right\rangle\cdot\Delta\mathbf{r}_j + O\left(\left|\Delta\mathbf{r}_j\right|^2\right)\right] \tag{3}$$

the latter can be recasted, on a first-order expansion of the momentum linear connections, as it follows:

$$\Phi = \lim_{\mathrm{d}\mathbf{r}\to 0}\mathbf{Im}\sum_j \ln\left\langle j\middle|U_{\mathrm{d}\mathbf{r}_j}\middle|j\right\rangle + O'\left(\left|\Delta\mathbf{r}_j\right|^2\right) \tag{4}$$

The state $U_{\mathrm{d}\mathbf{r}_j}\left|j\right\rangle$ is the infinitesimally shifted state with respect to the j^{th} state, making to acquire an infinitesimal phase $\mathrm{d}\theta_j$ to the quantum j^{th} state, can be considered as the total phase change:

$$\Phi = \lim_{\mathrm{d}\mathbf{r}\to 0} \mathbf{Im} \ln \Pi_j \left\langle j \middle| U_{\mathrm{d}\mathbf{r}_j} \middle| j \right\rangle \tag{5}$$

on evaluating the infinite product on the logaritmic function:

$$\Phi = \lim_{\mathrm{d}\mathbf{r}\to 0} \mathbf{Im} \ln \Pi_j \left\langle j \middle| j+1 \right\rangle = \lim_{\mathrm{d}\mathbf{r}\to 0} \sum_j \mathrm{d}\theta_j \tag{6}$$

showing finally quantum Selenu's phase being at the limit of an infinitesimal displacement of space coordinates, the quantum geometric phase acquired by the matter system along paths of the current flowing, connecting the initial point 0 to a final point p:

$$\Phi = \int_0^{[p]} \mathrm{d}\theta \tag{7}$$

The evaluation of the Selenu's phase (8) then calculated as the circulation of the linear momentum allows to determine the local variations of the quantum number of states on a phase of the system in order to recognize the latter making an interference pattern of the wave field functions itself making matter [9]. The knowledge of the gradient of the latter phase implies the knowledge of a local potential, which can be varied in order to calculate the linear momentum field, being also the former written as the gradient of the geometric quantum phase Φ of the system. In what follows, the case of a closed loop in space making a current flow [10] "across" the system is considered, also being here matter amplitudes associated to a space point varying phase, making then on a new built a quantum matter system on motion, as can be recorded either on a TEM [11] scattering process in the case of the recording of the amplitude of the electron field or else through the Aharonov-Bhom effect, where the latter acquires a geometric phase written on the following form:

$$\begin{aligned} \Phi &= \oint_C \mathrm{d}\theta \\ \Phi &= \oint_C \langle \nabla \rangle \cdot \mathrm{d}\mathbf{r} \end{aligned} \tag{8}$$

by Equation (1), can be shifted by the gauge unitary Aharonov phase transformation [4] $\Psi' = \mathrm{e}^{i\theta_A}\Psi$, being $\mathrm{e}^{i\theta_A} = \mathrm{e}^{i\int_0^{[p]} A\cdot\mathrm{d}\mathbf{r}}$, then allowing to quantify the change of the quantum linear momentum of the system, as a variation of the quantum geometric phase of the wave fields:

$$\Phi = \oint_C \mathrm{d}\theta + i\oint_C \langle A \rangle \tag{9}$$

Latter result represents the prototype experiment of the Aharonov-Bohm effect where the appearance of a magnetic field on quantum matter of electrons generated by Equation (9) a change of the phase making the interference pattern on the Aharonov-Bohm effect in quantum matter [5] [12] where the former change is due to the existence of a magnetic field in space given by the circulation of a macroscopic potential vector on Equation (9). The article is concluded having shown the existence of a solution of the debated topic [1] [2] [7] made during the last century never understood until this work, of the system being onto acquire a quantum geometric phase on a general transformation, where also clearness has been put on regard to the nature of the momentum linear connection of the system itself (otherwise called linear momentum in units of $\hbar$), shown to reside on the translational properties of the wave field functions that of making acquire a quantum phase to the field of the physical system on its circulations [13] [14], determining also whether the appearance of a potential vector generates the phase change of the quantum field itself on making a change of the linear momentum.

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Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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