QUANTUM MECHANICS AS A SPACE-TIME THEORY

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ABSTRACT. The aim of the talk is to explore how quantum mechanics can be understood as a space-time theory.[1] We will only consider systems of massive Galilean-relativistic quantum particles and we will focus on the concept of localization.

The analysis starts with points, which represent the quantum particles, and examines their topological and metrical relations. Their topological relations describe how the points are located amongst themselves and do not depend upon the choice of the metric[11]. We will discuss how the ordering of the locations of the physical points can effect the choices of the topological structure.

We use the Gauss-Riemann approach in which the location of points is realized using coordinates. The use of coordinates involves two choices; we can choose a real number system to be used along each coordinate axis and then, for that real number system, choose a basis from the possible coordinate bases. The physics of the geometry should be independent of these choices but we claim that the choice of a real number system has empirically verifiable consequences.

Previously, we have shown how to remove certain gaps in the standard quantum theory by enlarging the class of real number values taken by physical quantities [6]. The physical quantities take values given by non-standard real numbers that we call quantum real numbers (qrumbers). The rational numbers, which are obtained in measurement processes, are densely embedded in the qrumbers. The qrumbers are constructed from mathematical entities in the standard Hilbert space formalism using topos theory[2], [10]. Each qrumber has an extent that is given by an open subset of the standard state space of the quantum system. This leads to the identification of an open subset of state space as a complete state in the sense that an open set determines the qrumber values of all physical quantities[8].

We will use qrumbers to realize the topology of the points in quantum space. For a single quantum particle, the points are labelled by triplets of qrumbers. Because the numerical values of a particle's position are taken to be attributes of the particle, each quantum system has its own quantum space. A particle that is localized in its quantum space may be non-localized when viewed from the classical space. This raises questions about the relationship between classical and quantum space.

We also discuss multi-particle systems. For example, we consider Bell's experiment for two massive identical spin-1/2 particles [3]. When the standard experiment is described using qrumbers we can show that the qrumber distance between the identical particles is zero at the time that the spin measurements in the classically separated Stern-Gerlach apparatuses are carried out. We compare this with the Bohmian picture [5] in which the separation is zero only in average [9].

References

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