The recently introduced Quantum Theory of Time (QTT) [1] describes the space-time wavefunction of a scalar particle as a 4-dimensional Gaussian, which is analogous to the s-orbital in atomic physics. This immediately suggests that a fermionic particle may be described in QTT by a wavefunction that is Gaussian in the radial component and periodic in the angular coordinates. To investigate this, we explore the possibility of deriving a solution to the Dirac equation [2] that is a 4-dimensional local wavefunction centred on the centre-of-mass coordinates. The overarching goal is to reinterpret the internal degrees of freedom of a Dirac fermion (particularly the electron) as a local wavefunction that is oriented in 4-dimensional space and time.

There has been some previous work exploring the local shape of an electron spinor, in terms of a generalised spherical-harmonic description of the wavefunction of a spin-1/2 particle. For example, Gatland [3] found that the angular momentum raising and lowering operators permit an odd number of states and thus forbade eigenstates with eigenvalues that are multiples of \( \hbar \). Furthermore, Rubin [4] was able to compute eigenvalues of the Laplacian of symmetric transverse traceless tensor harmonics for dimensionality \( \geq 3 \). He proved that the tensor harmonics occupy the space described by the original symmetric transverse traceless tensors, allowing easier linking of spherical harmonics to the electron spinor.

QTT attributes a localised Gaussian wavefunction in space and time to any particle, including a fermion, opening up further ways to explore the problem. In particular, we begin with a composite system of two 2-dimensional spin-1/2 particles to represent a single 4-dimensional spinor which we re-express in terms of a direct sum of \( L=0 \) and 1 angular momentum basis states. Finally, we use the corresponding spherical harmonic functions to show that a fermion is represented in QTT as a wavefunction that is localised both in time and the radial spatial coordinate like a scalar particle, but differs from a scalar particle in that it has additional angular variation in space.

See Also:


