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INCLUSION OF BREIT-PAULI SHORT-RANGE INTERACTIONS IN THE QUANTUM MECHANICAL THEORY OF SUB-ATOMIC SYSTEMS

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ABSTRACT

Following the introduction of the Schrödinger and Dirac quantum mechanical equations for the description of hydrogenic atoms, there was a longstanding attempt to develop a similar approach which is applicable to the treatment of nuclear reactions. There was consensus that interactions of shorter range than the Coulomb force are involved, but there was also the strongly held view that the corresponding Hamiltonian that satisfies this requirement must be invariant to a Lorentz transformation. The latter conclusion is questioned on the basis of a simple example involving the interaction of an electron in an electromagnetic field. It leads to a contradiction according to which observers in different rest frames must disagree on whether the path of the electron is curved or linear. A solution to this dilemma is provided by the assumption of a different definition of the velocity parameter v in the Lorentz Force law, specifically that it is taken to be the speed of the electron relative to the origin of the electromagnetic field rather than to each observer. Moreover, the requirement that the Hamiltonian operator be invariant to a Lorentz transformation is shown to be satisfied by merely employing the same form for the operator in each rest frame. A problem with the limiting behaviour of the Breit-Pauli Approximation short-range terms such as spin-orbit and spin-spin coupling is shown to be eliminated by multiplying them with a momentum-dependent exponential factor similar to that advocated much earlier by Yukawa in connection with his theory of elementary particle interactions. The relation between the internal motion of the particles and that of the centre of mass of the system is also discussed. The evaluation of properties in rest frames moving with high velocity relative to the centre of mass of the system under consideration can be undertaken with the aid of the Uniform Scaling procedure rather than by explicit computation of expectation values based on solutions in which the effects of internal and translational motion are intertwined.

KEYWORDS: *Schrödinger Equation, Dirac Equation, Breit-Pauli Approximation, Uniform Scaling, Exponential Damping, XBPS Model*

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