

The Inconsistency of the Usual Galilean Transformation in Quantum Mechanics and How To Fix It

Daniel M. Greenberger

City College of New York, New York, NY 10031, USA

Reprint requests to Prof. D. G.; dansuzy@idt.net

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It is shown that the generally accepted statement that one cannot superpose states of different mass in non-relativistic quantum mechanics is inconsistent. It is pointed out that the extra phase induced in a moving system, which was previously thought to be unphysical, is merely the non-relativistic residue of the “twin-paradox” effect. In general, there are phase effects due to proper time differences between moving frames that do not vanish non-relativistically. There are also effects due to the equivalence of mass and energy in this limit. The remedy is to include both proper time and rest energy non-relativistically. This means generalizing the meaning of proper time beyond its classical meaning, and introducing the mass as its conjugate momentum. The result is an uncertainty principle between proper time and mass that is very general, and an integral role for both concepts as operators in non-relativistic physics.

Key words: Galilean Transformation; Symmetry; Superselection Rules; Proper Time; Mass.