To Professor Schönberg, with the compliments of Takao Tati.

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Quantum Mechanics, Relativity and Causality. A Proposal to Test the Existence of a Universal Timelike Vector Governing Causal Relations.

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Summary. — In quantum mechanics, the state is prepared by a measurement on a spacelike surface σ. What is that determines the surface σ on which the measurement prepares the state? It is considered either a mechanism proper to the measuring process (apparatus) or a universal property of space-time. In the former case, problems arise, concerning causality or conservation of probability due to the fact that the velocity of reduction of a wave packet is considered to exceed the light velocity. The theory of finite degree of freedom proposed previously belongs to the latter case. In this theory, the surface σ is restricted to the hyperplane perpendicular to a universal timelike vector governing causal relations. We propose an experiment to discriminate between the above-mentioned two cases and to test the existence of the universal timelike vector.

1. – In quantum mechanics, the state Ψ_1 is prepared by a measurement of a complete set of observables and the solution $\Psi(t)$ of the Schrödinger equation with the initial condition Ψ_1 gives the probability amplitude for the next measurement after the time interval t. This description is nonrelativistic in the sense that the time t depends on the reference system of the observer. In order to have a relativistic formulation, the super-many-time theory generalizes the probability amplitude so that it is given on an arbitrary spacelike surface σ, by assuming that the measurement of observables which are point functions on an arbitrary surface is possible. The probability amplitude $\Psi[\sigma]$ on an arbitrary σ is defined mathematically as a solution of the Tomonaga-Schwinger

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