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MEASUREMENT BY PHASE SEVERANCE*

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We assert that the measurement process is more accurately described by the phrase "quasi–local phase severance" than by "wave function collapse". The basic theory we use already exists;[1] we emphasize here that it provides a straightforward resolution of the "measurement problem," a fact that was not emphasized in the original presentation.

Our approach starts from the observation by T. E. Phipps, Jr.[2] that the usual route to quantum mechanics starting from the Hamilton–Jacobi equations throws away half the degrees of freedom, namely the classical initial state parameters. As he remarks elsewhere,[3] "I'm pretty absent mined myself, but when it comes to counting parameters, I'll take on any performing horse (or non–performing physicist)." His way of meeting this difficulty is to interpret the full set of Hamilton-Jacobi equations as operator equations acting on a state vector Ψ. When Ψ is a constant, the classical theory is obtained, while the assumption that the action has the constant value h/i leads to the conclusion that Ψ is the conventional

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Schrödinger wave function $\Psi_{\text{Schröd.}}$ multiplied by the phase factor $e^{-i\Sigma_r P_r Q_r}$; here P_r, Q_r are the classical initial state constants of the motion. For "Class I" theories the state vector is constant and for "Class II" theories the action is constant. When neither the action nor the state vector are constant, Phipps develops a "Class III" theory which modifies conventional quantum mechanics inside distances of the order of the classical election radius. This theory is not, as yet, in obvious conflict with experiment, but careful tests have not been made. Clearly the predictions of any Class II theory based on $|\Psi|^2$ are conventional; however, the interpretation of the classical parameters in the unobservable phase factor provides us with a useful flexibility.

The framework we use for constructing our measurement theory is the conventional S-matrix boundary condition of N_A free particles in the distant past and N_B free particles in the distant future. Interactions occur in a finite and bounded macroscopic (laboratory) region that is geometrically inferred from macroscopic measurements (sizes of slits, collimators, counters, etc.). We take the usual free particle wave functions

$$\Psi_C = \exp\left(i\sum_{r=1}^{N_C} \underset{\sim}{p}_r^C \cdot \underset{\sim}{q}_r^C\right) - (E_C + i\,0^+)t \;; \quad C = A, B$$

for granted but multiply them by the Phipps phase factors. We assume that (a) the final wave function (Ψ_B) is proportional to the initial wave function (Ψ_A) and (b) that the Phipps phase factor cannot lead to observable interference effects. These conditions, completely determine the form of the transition amplitude. It is simply the usual formula of the Goldberger-Watson scattering theory.[4]

The original papers (Refs. 1 and 3) were aimed at achieving a separation between the kinematics of quantum scattering theory from the dynamics of specifying the transition amplitudes. The motivation was the need for a dynamical theory of Fadduv-Yakubovsky or Alt-Grassberger-Sandhas type which could be directly postulated and did not have to be derived from a "Hamiltonian". The need arises from the fact that there are an infinite number of interaction terms in a Hamiltonian which predict the same observables in the laboratory creating an infinite source of ambiguity in the theory of strong interactions. Further, since the free particle basis states are manifestly covariant, another source of ambiguity is removed by this approach. Our dynamical theory turned out to be considerably more difficult to develop than was anticipated in 1975, but it now exists.[5]

We pointed out in our earlier papers that the Phipps phase factors (unobservable by construction) can be interpreted as specifying the non-local space time points where the N_A initial state particles disappear and the N_B points where the final state particles appear. Taking this interpretation one step further, this fully covariant final state impinges on N_B, or fewer, detectors which can also be viewed as scattering volumes. Each of these quasi-local (*i.e.* macroscopic) devices amplifies some scattering event (usually an ionization) initiated by one of the particles, and if recorded "collapses" the portion of the wave function referring to that particular particulate degree of freedom. Note that it does not destroy the coherence (and hence the possibility of interference) among the undetected particles – the unresolved degrees of freedom. These may or may not subsequently impinge on additional detectors. As I remarked (Ref. 3, p. 23).

"From this point of view, the probe does not 'create' Ψ_B, but simply informs us that from now on we can make more precise (in the statistical sense) predictions of the future by constructing a new wave function incorporating the new information. Whether or not we exercise this option is a matter of choice and in no way affects the actual course that the system follows.

"We would be foolish to ignore the possibility of using the information given by the probe for future predictions, but history reveals all too clearly that there is no law of nature that prevents physicists from being foolish."

This attitude allows one to analyze the particulate double slit experiment with counters in both slits and shows how the interference pattern shifts continuously from one double slit pattern to two single slit patterns as the density of the material in the counters is increased.[6] So far as we can see, the consequences of our point of view are identical with those of the "many Hilbert spaces" theory subsequently developed by Machida and Namuki.[7] We are in complete agreement with their analysis of the neutron interference experiments performed a phase shifter in one path and a spin flipper in none, one or both of the paths.[8] They refer to their analysis as the "Copenhagen Interpretation", but we think this is not quite correct since the scattering theory they use did not exist 60 years ago. We view their work (like our own) as a much–needed clarification of the implications of quantum mechanics. As Bastin has often insisted, there are many different "Copenhagen interpretations" with considerable consequent ambiguity. In the case at hand Vigier comes to a different conclusion than that of Namuki, Otake and Soshi as to what the Copenhagen interpretation is supposed to say.

Although the phase severance description of the measurement process presented here is "quasi–local", it in no way removes the extreme non–locality of quantum mechanics such as that exhibited in the "eternal triangle effect".[9] As we have shown elsewhere,[10] the postulates of finiteness, discreteness, finite computability, absolute non–uniqueness and additivity lead directly to the necessity for a unique limiting velocity for causal (information transmitting) interactions, yet at the same time predict supraliminal correlation (synchronization) such as most physicists believe to have been observed in Aspect's, and other EPR-Bohm type experiments. The quasi–locality of particle detection we invoke above in no way contradicts these acausal, supraliminal effects.

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