Quantum probability from causal structure

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The Born probability measure describes the statistics of measurements in which observers self-locate themselves in some region of reality [1]. In ψ-ontic quantum theories, reality is directly represented by the wavefunction. We show that quantum probabilities may be identified with fractions of a universal multiple-time wavefunction containing both causal and retrocausal temporal parts. This wavefunction is defined in an appropriately generalized history space on the Keldysh time contour [2]. Our deterministic formulation of quantum mechanics replaces the initial condition of standard Schrödinger dynamics with a network of 'fixed points' defining quantum histories on the contour. The Born measure is derived by summing up the wavefunction along these histories. We then apply the same technique to the derivation of the statistics of measurements with pre- and post-selection [3].

[1] Sebens, C. T. and Carroll, S. M. "Self-locating uncertainty and the origin of probability in Everettian quantum mechanics". The British Journal for the Philosophy of Science, 69(1), 25-74 (2018).

[2] van Leeuwen, Robert, et al. "Introduction to the Keldysh formalism". Time-dependent density functional theory. Springer, Berlin, Heidelberg, 2006. 33-59.

[3] Aharonov, Yakir, and Vaidman, Lev. "The two-state vector formalism: an updated review". Time in quantum mechanics (2008): 399-447.