

Spontaneous unitarity violation as a model for quantum state reduction

Aritro Mukherjee, Lotte Mertens, and Jasper van Wezel

University of Amsterdam, Science Park 904, Amsterdam, Netherlands

The impossibility of describing measurement in quantum mechanics while using a quantum mechanical model for the measurement machine, remains one of its central problems. Objective collapse theories propose a solution to this problem by predicting deviations from Schrödinger's equation that can be tested experimentally. A class of objective theories based on spontaneous unitarity violation was recently introduced, which complements existing proposals based on stochastic modifications of Schrödinger's equation, but also differs from them in several aspects. Here, we contrast the stochastic dynamics encountered in both types of models, and highlight the unique features of spontaneous unitarity violation as well as their implications.

In particular, we will show that the physical requirements of the stochastic field being independent of the state to be measured and having non-vanishing correlations time, imply a unique form for the measurement dynamics of an isolated two-level system. Building on this minimal example, we show that the dynamics has a natural extension to systems with an arbitrary number of basis states, that it reduces to a purely dephasing Lindblad equation (and hence is explicitly norm-preserving and non-signalling) in the limit of vanishing correlation time, and that Born's rule emerges in the limit of macroscopic measurement machines, without the stochastic field depending in any way on the state being measured. For each of these results we will contrast their implementation and implications with other types of modified Schrödinger dynamics. We will conclude with a discussion of accessible signatures distinctive for spontaneous unitarity violation in experimental tests of quantum state reduction.