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Weak values and the Leggett-Garg inequality in solid-state qubits

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The seminal paper of Aharonov, Albert, and Vaidman introduces the concept of a weak value as a statistical average over realizations of a weak measurement, where the system is both pre- and post-selected. By taking restricted averages, weak values can exceed the range of eigenvalues associated with the observable in question. We discuss how to implement a weak values measurement with solid-state qubits. In parallel activity, Leggett and Garg have devised a test of quantum mechanics for a single system using different ensembles of (projective) measurements at different times and correlation functions of those outcomes. The original motivation was to test if there was a size scale where quantum mechanics would break down. Introduced as a “Bell-inequality in time”, the assumptions of macrorealism that could be verified by a non-invasive detector imply that their correlation function obeys a Leggett-Garg inequality that quantum mechanics would violate, formally similar to the inequality of Bell. We demonstrate that the proper notion of a classical weak value also demands these assumptions, and that furthermore a weak value can be non-classical if and only if a Leggett-Garg inequality can also be violated. We will discuss generalized weak values, where post-selection occurs on a range of weak measurement results. Our analysis is presented in terms of kicked quantum nondemolition measurements on a quantum double-dot charge qubit.