

Critical Unstable Qubits

Tuesday, September 23, 2025 4:30 PM (30 minutes)

By employing the Bloch-sphere formalism, I will present a novel class of unstable qubits, which are called Critical Unstable Qubits (CUQs). The characteristic property of CUQs is that the energy-level and decay-width Pauli vectors, E and Γ , are orthogonal to one another, and the key parameter $r = |\Gamma|/(2|E|)$ is less than 1. A remarkable feature of CUQs is that they exhibit atypical behaviours like coherence-decoherence oscillations when analysed in an appropriately defined co-decaying frame of the system. In the same frame, I will show how a unit Bloch vector b describing a pure CUQ sweeps out unequal areas during equal intervals of time, while rotating about the vector E . These phenomena emerge beyond the usual oscillatory pattern due to the energy-level difference of a standard two-level quantum system. I will illustrate how these new features are relatively robust and persist even for quasi-CUQs, in which the vectors E and Γ are not perfectly orthogonal to each other. I discuss potential applications of our results to quantum information and to unstable meson-antimeson and other systems.

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