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Population Inversion and Mesoscopic Fluctuations in Strongly Driven Artificial Atoms

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Abstract:

Population inversion (PI) is among the most interesting phenomena in maser and laser physics. The usual mechanism to get PI, *i.e.* the most highly populated state is an excited state, requires driven quantum systems with three or more energy levels.

Interesting systems to study PI are `artificial atoms' made with mesoscopic Josephson devices.

Among them, is the flux qubit (FQ), which for millikelvin temperatures exhibits quantized energy levels that are sensitive to an external magnetic field.

Population inversion was observed in the FQ for ac amplitudes that excite to the third and fourth energy levels through Landau-Zener transitions.

In this talk I will show that an even more notable effect is awaiting to be observed if the ac driving pulses are applied for longer time scales: PI could be observable even for ac amplitudes where only the two lowest levels of the FQ participate, thus solely mediated by the environmental bath. Furthermore, the degree of population inversion can be controlled by tailoring a resonant frequency W in the environmental bath.

In addition we investigate the effect of time reversal symmetry broken in artificial atoms in contact with an environmental bath. Using as a test system the FQ driven by a biharmonic magnetic signal of period τ with a phase lag, it is possible to establish a direct analogy between interference effects at avoided level crossings and scattering events in mesoscopic disordered media. As we show, the phase lag acts as effective time reversal control parameter that enables to study mesoscopic signatures in the transition rate, like weak localization and fluctuations effects.

References:

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A. Ferrón, D. Dominguez and M. J. Sánchez, ***Pys. Rev. Lett. 109, 237005 (2012)***