Quantum Bistability at the Interplay Between Collective and Individual Decay

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We study driven collective radiation of an ensemble of atoms placed inside a cavity, accounting for individual-atom emission to free space modes. We find that the steady state exhibits a dissipative phase transition, formed by a mixture of two collective quantum states corresponding to a bistable mean-field solution. One of these states is entangled and closely resembles a coherently radiating spin state (CRSS) – the solution obtained by neglecting individual decay (Dicke superradiance) – allowing us to analytically find the optimally achievable spin squeezing. We predict quantum switching between the two states, verified by quantum trajectories simulations. The switching rate tends to vanish with the atom number, as the Liouvillan gap closes. Remarkably, this suggests that the system may reside in an entangled CRSS-like state associated with correlated Dicke physics, even in the presence of decorrelating individual decay. This opens a path for a systematic study of the interplay between collective and individual decay, in both experiments and theory.

References

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