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Floquet-Gibbs states in laser-driven atomic systems

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Periodically driven quantum systems in a thermal environment generically settle to a Floquet-Gibbs state in a rotating frame, which is stable on long-time scales, provided that the driving frequency is high enough. However, in laser-driven atomic systems, which is a versatile platform for quantum technologies, the situation is typically more complicated, since the corresponding Hamiltonian is time-independent only in the rotating frame of the laser. If such systems are exposed to periodic variations of external parameters, their actual Hamiltonian usually becomes a quasi-periodic function of time. It is then no longer clear whether a generic stationary state exists and how it can be described, even in the high-frequency limit. We argue that systems of this type approach a stable Floquet-Gibbs state in an interaction picture that is connected to the Schrödinger picture by a quasi-periodic unitary transformation, provided that the laser frequency and the additional driving frequency are well separated and large compared to both the typical Bohr frequencies of the bare system in the rotating frame, and the typical energy exchanged in single-photon system-bath interactions. The Floquet-Gibbs state is determined by the temperature of the reservoir and an effective Hamiltonian that can be obtained from a Floquet-Magnus expansion. To demonstrate the validity of our arguments, we compare the exact solution of the time-dependent Redfield equation for a generic many-body system composed of Rydberg atoms or ions with the corresponding Floquet-Gibbs state.

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