

# Quantum Master Equation Approach to Periodically Driven Superconductors

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Controlling material properties in periodically driven open systems has attracted growing interest. Periodic driving can dynamically modulate band structures and interactions [1]. Dissipation suppresses drive-induced heating and determines nonequilibrium states by redistributing excitations [2]. Because superconducting order is sensitive to both the electronic distribution and the pairing interaction, combining periodic driving and dissipation offers a promising route to designing desired superconducting states.

Quantum master equations provide a unified description of driving and dissipation [3]. The superconducting order parameter is determined by the electronic state and also influences electronic relaxation. This feedback requires solving the gap equation and the quantum master equation self-consistently. However, such a framework is not yet well established for periodically driven open systems.

In this study, we derive quantum master equations for periodically driven superconductors coupled to thermal baths and develop a self-consistent framework for determining superconducting order [5]. We show that, within the Born–Markov approximation, our approach reproduces the nonequilibrium steady-state superconducting gap obtained using the Floquet Green’s function method [4,5] (Fig. 1). Furthermore, the framework readily incorporates an energy-dependent bath density of states. Going beyond the commonly assumed constant density of states, we clarify how its energy dependence affects superconducting order [5].

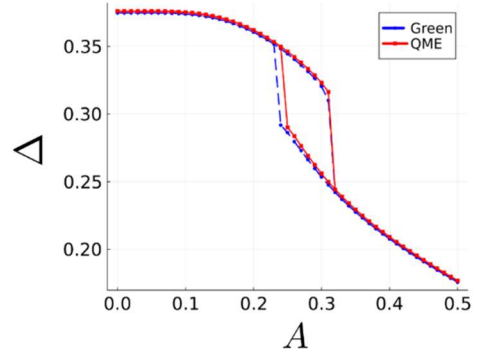


Fig. 1. Gap  $\Delta$  versus drive amplitude  $A$ . Blue: Floquet Green’s function; red: quantum master equation.

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