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Homoclinic chaos in a pair of parametrically-driven coupled SQUIDs

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Abstract

An rf superconducting quantum interference device (SQUID) consists of a superconducting ring interrupted by a Josephson junction (JJ). When driven by an alternating magnetic field, the induced supercurrents around the ring are determined by the JJ through the celebrated Josephson relations. This system exhibits rich nonlinear behavior, including chaotic effects. We study the dynamics of a pair of parametrically-driven coupled SQUIDs arranged in series. We take advantage of the weak damping that characterizes these systems to perform a multiple-scales analysis and obtain amplitude equations, describing the slow dynamics of the system. This picture allows us to expose the existence of homoclinic orbits in the dynamics of the integrable part of the slow equations of motion. Using high-dimensional Melnikov theory, we are able to obtain explicit parameter values for which these orbits persist in the full system, consisting of both Hamiltonian and non-Hamiltonian perturbations, to form so-called Silnikov orbits, indicating a loss of integrability and the existence of chaos. Extensive numerical analysis requiring algorithms of rapid numerical integration are required to follow the solutions for long times and verify the accuracy of the analytical results.

Key words: superconducting quantum interference device, Josephson junction, Near-Integrable Hamiltonian Systems, Silnikov Chaos, Numerical Simulations