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Modeling of Physical Phenomena in Superconducting Nanostructures

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We study the resonance phenomena in the intrinsic Josephson junctions shunted by LC-elements (L-inductance, C-capacitance). A realization of parametric resonance through the excitation of a longitudinal plasma wave, within the bias current interval corresponding to the resonance circuit branch, is demonstrated. It is found that the temporal dependence of the total voltage of the stack, and the voltage measured across the shunt capacitor, reflect the charging of superconducting layers, a phenomenon which might be useful as a means of detecting such charging experimentally. Thus, based on the voltage dynamics, a novel method for the determination of charging in the superconducting layers of coupled Josephson junctions is proposed. A demonstration of the influence of external electromagnetic radiation on the IV-characteristics and charge-time dependence is given. Over certain parameter ranges, the radiation causes an interesting new type of temporal splitting in the charge-time oscillations within the superconducting layers. We show that the amplitude dependence of the Shapiro step width crucially changes when the Shapiro step is on the resonant circuit branch.
When a barrier in the Josephson junction is a noncentosymmetric, then unusual current-phase relation with a phase shift proportional to the magnetic moment perpendicular to the gradient of the asymmetric spin-orbit potential is realized. Such Phi_0 Josephson junctions demonstrate a number of unique features important for superconducting spintronics and modern informational technologies. Here we show that a current sweep along IV-characteristic may lead to both regular and chaotic magnetization dynamics with a series of specific phase trajectories. We demonstrate an appearance of DC component of superconducting current and clarify its role in the transformation of IV-characteristics in resonance region. The presented results might be used for developing novel resonance methods of determination of spin-orbit coupling parameter in the noncentrosymmetric materials.

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