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Theory of two-dimensional macroscopic quantum tunneling in YBa$_2$ Cu$_3$ O$_{7-\delta}$ Josephson junctions coupled to an LC circuit

Shiro Kawabata, Thilo Bauch, Takeo Kato

(Submitted on 13 Jan 2009 (v1), last revised 4 Nov 2009 (this version, v2))

We investigate classical thermal activation (TA) and macroscopic quantum tunneling (MQT) for a YBa$_2$Cu$_3$O$_{7-\delta}$ (YBCO) Josephson junction coupled to an LC circuit theoretically. Due to the coupling between the junction and the LC circuit, the macroscopic phase dynamics can be described as the escape process of a fictitious particle with an anisotropic mass moving in a two-dimensional potential. We analytically calculate the escape rate including both the TA and MQT regime by taking into account the peculiar dynamical nature of the system. In addtion to large suppression of the MQT rate at zero temperature, we study details of the temperature dependece of the escape rate across a crossover region. These results are in an excellent agreement with recent experimental data for the MQT and TA rate in a YBCO biepitaxial Josephson junction. Therefore the coupling to the LC circuit is essential in understanding the macroscopic quantum dynamics and the qubit operation based on the YBCO biepitaxial Josephson junctions.

Comments:	13pages, 7 figures, 1 table, to appear in Phys. Rev. B 80 (2009)
Subjects:	**Superconductivity (cond-mat.supr-con)**; Mesoscale and Nanoscale Physics (cond-mat.mes-hall); Quantum Physics (quant-ph)
Journal reference:	Phys. Rev. B 80 (2009) 174513
DOI:	10.1103/PhysRevB.80.174513
Cite as:	**arXiv:0901.1723v2 [cond-mat.supr-con]**

Submission history

From: Shiro Kawabata [view email]
[v1] Tue, 13 Jan 2009 08:09:24 GMT (661kb)
[v2] Wed, 4 Nov 2009 01:39:12 GMT (1119kb)

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