Noisy dynamics in long and short Josephson junctions

C. Guarcello[1], D. Valenti[2], A. Carollo[2], B. Spagnolo[2]

[1]NEST, Istituto Nanoscienze-CNR and Scuola Normale Superiore, Pisa, Italy

[2]University of Palermo, Interdisciplinary Theoretical Physics Group, Palermo, Italy

The transient dynamics of different Josephson junctions (JJ) in noisy environments is computationally explored, looking several interesting cases.

First, the lifetime in the superconducting metastable state of a long JJ (LJJ) is studied. Specifically, we study the dynamics of the phase , i.e., the phase difference between the macroscopic wave functions in the two electrodes, governed by the perturbed sine-Gordon equation. We focus on the mean switching time (MST) from the superconducting state to the resistive state, in the presence of an external noise source modeled by -stable Lvy distributions. These statistics allows to describe real situations, in which abrupt jumps and very rapid variations of the order parameter occur (Lvy flights). The MST shows non-monotonic behaviors, according to the influence of noise induced solitons.

The features of a short ballistic graphene-based JJ is also studied through the RCSJ model. The supercurrent deviates from the usual sinusoidal behavior expected for tunnel JJs, nevertheless this system is still characterized by metastable states. In our work, the mean first passage time from these metastable states is calculated in the presence of white and correlated Gaussian noise sources, and noise induced phenomena are observed. The study of the probability density function of the escape times is also performed. Moreover, we investigate the noise induced switching, when the external bias current is linearly ramped to retrieve the switching current distribution (SCD), i.e. the probability distribution of the passages to finite voltage as a function of the bias current, that is the information more promptly available in the experiments. We consider two different noise sources, i.e. Gaussian for the thermal bath and non-Gaussian Lvy distribution. We show how it is possible to discriminate the noise source features through the analysis of the SCD.

We also investigate the generation of breathers in LJJ, as a proper external magnetic field drives the system. Considerable amount of theoretical study about breathers exists, despite the absence of experimental works devoted to their detection in LJJ. This study is devoted to establish an efficient experimental setup to generate breathers in a LJJ. For specific values of the drive amplitude A and frequency , only breathers along the JJ are observed. Otherwise, combinations of solitons, breathers, and plasma waves set along the JJ.

[l] D. Valenti, C. Guarcello, a, Phys. Rev. B **89**, 214510 (2014).

[2] C. Guarcello, D. Valenti, A. C, J. Stat. Mech.: Theo **054012**, 054012 (2016).

[3] C. Guarcello, D. Valenti, and, Phys. Rev. B **92**, 174519 (2015).

[4] B. Spagnolo, D. Valenti, C. Gu, Chaos, Sol. & Frac. **81**, 412 (2015).

[5] C. Guarcello, D. Valenti, Nanotechnology **28**, 134001 (2017).