Contribution ID: **1641** Type: **Oral**

Toolkit in Python for simulation of controllable magnetization reversal in a chain of Phi-0 junctions by an alternating voltage pulse

Monday 28 October 2024 16:30 (15 minutes)

Within the framework of the joint project of LIT and BLTP JINR, a toolkit is being developed for investigation of systems containing Josephson junctions based on Jupyter using Python libraries. It should be noted that a number of tasks require numerous resource-intensive calculations, which leads to the need for significant acceleration of computational schemes implemented in Python and the development of parallel algorithms. The results of investigations will are placed as the Jupyter Book, containing physical and mathematical formulations of problems, developed algorithms, computational schemes, which allows to follow all stages of mathematical modeling with interactive and visual elements, and the user can also download a ready-made Jupyter Notebook for their own research.

In this work we present the results of investigations of controllable magnetization reversal and developed tools for its modeling. The interest in this system is due to the fact that the possibility of developing of cryogenic memory based on the magnetization reversal in a Phi-0 junction has been actively studied recently. In Phi-0 Josephson junctions, the spin-orbit interaction in a ferromagnetic layer without an inversion center provides a mechanism for direct coupling between the magnetization and the superconducting current, which makes it possible to control the magnetic properties by means of the Josephson current, as well as the effect of magnetization on the Josephson current. However, in case of using several Phi-0 junctions in a single chip, there is a need to implement a magnetization reversal in a selected Phi-0 junction. We propose a solution to this problem based on mathematical modeling of the dynamics of a system consisting of three Phi-0 junctions connected via LCR circuits, which is reduced to solving the Cauchy problem.

The results of the development of a toolkit for modeling a controllable magnetization reversal in a chain of Phi-0 junctions using alternating voltage are also presented. It is shown that by applying an alternating external voltage pulse with a frequency coinciding with the eigenfrequency of the LCR circuit, it is possible to realize a magnetization reversal in a selected Phi-0 junction, i.e. the possibility of a controllable magnetization reversal is demonstrated. The influence of system parameters on the magnetization dynamics in each of the Phi-0 junctions is studied in detail. A software module for the performed calculations is developed. The investigations were carried out on the basis of the ML/DL/HPC ecosystem of the heterogeneous HybriLIT platform (JINR LIT).

The work was carried out with the support of the Russian Science Foundation within the framework of project No. 22-71-10022.

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Session Classification: Mathematical Modelling and Computational Physics

Track Classification: Mathematical Modeling and Computational Physics