ac Josephson effect and resonant superconducting transport through vibrating Nb nanowires

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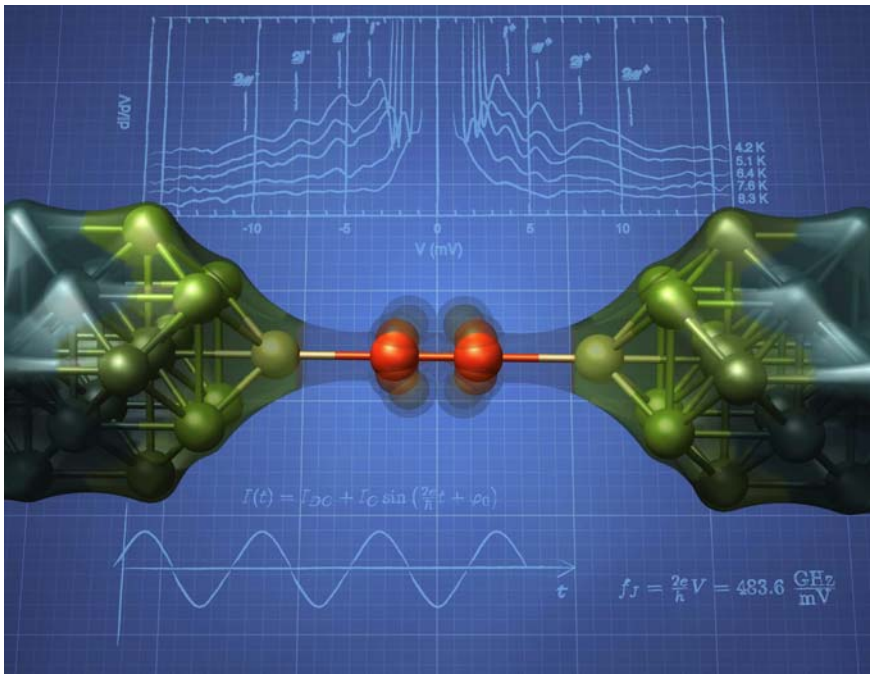
The generation of high-frequency current oscillations when a constant voltage is applied across an insulating tunnel gap separating two superconductors was one of the celebrated predictions made by Brian Josephson in 1962. These oscillations are ubiquitous in superconducting weak links of various geometries, and their analogues have also been found in other macroscopic quantum systems, such as superfluids and gaseous Bose-Einstein condensates. The phenomenon has been confirmed by studying changes in the current-voltage characteristics of superconducting tunnel junctions caused by the interplay of the oscillating current with externally applied microwave radiation of matching frequency (Shapiro steps) or with internal electrodynamic resonances (Fiske effect). I will present measurements and theoretical studies suggesting that Josephson current oscillations interact with atomic-scale mechanical motion as well [1]. We generated a niobium dimer (Nb_2) that acts as a weak-link between two superconducting (bulk) niobium electrodes [2]. We find features in the differential conductance through the dimer which correspond to excitations of the dimer vibrational eigenmodes by Josephson oscillations and support our results with theoretical simulations.



Atomic-scale mechanical motions in nanowires can be excited by high-frequency alternating Josephson current.

In niobium dimer nanowires three vibrational modes were experimentally observed and identified through first-principles theoretical calculations.

(Image: Georgia Tech/Alexei Marchenkov)

References:

[1] A. Marchenkov, Z. Dai, B. Donehoo, R. N. Barnett, and U. Landman, Nature Nanotech. **2**, 481 (2007).

[2] A. Marchenkov, Z. Dai, C. Zhang, R. N. Barnett, and U. Landman, Phys.Rev.Lett. **98** 046802 (2007).