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Emission of Coherent THz-Radiation from Superconductors.

ULRICH WELP, Argonne National Laboratory

Josephson junctions naturally convert dc-voltages into high-frequency electromagnetic radiation, with 1 mV corresponding to 0.483 THz, and many such junctions emitting in phase at the same frequency can produce useful emission power. Stacks of junctions with unsurpassed packing density occur naturally in the layered high temperature superconductor $Bi_2Sr_2CaCu_2O_8$, in which the superconducting CuO_2-layers are coupled through the intrinsic Josephson effect. However, achieving synchronization of the high-frequency oscillations of all the junctions in the stack has so far been a major challenge. We demonstrate that coherent continuous-wave THz-radiation of sizable power can be extracted from intrinsic Josephson junctions in the layered high-temperature superconductor $Bi_2Sr_2CaCu_2O_8$. In analogy to a laser cavity, the excitation of an electromagnetic cavity resonance inside the sample generates a macroscopic coherent state in which a large number of junctions are synchronized to oscillate in phase. The emission power is found to increase as the square of the number of junctions reaching values of 0.5 μW at frequencies up to 0.85 THz. The available power is potentially much larger, as there is evidence that 20 μW of power are pumped into the observed THz cavity resonance. The emission persists up to temperatures of $\sim$50 K. Emission does not require the application of a magnetic field, significantly simplifying the design of superconducting THz-sources. In fact, a single applied D.C. current leads to the efficient excitation of continuous coherent THz-radiation. This work was supported by the U.S. Department of Energy under Contract No. DE-AC02-06CH11357 – Basic Energy Sciences, the Japanese Ministry of Education, Culture, Sports, Science and Technology, and the Turkish TUBITAK under Project No. 106T053. In collaboration with L. Ozyuzer, A. E. Koshelev, C. Kurter, N. Gopalsami, Q. Li, M. Tachiki, K. Kadowaki, T. Yamamoto, H. Minami, H. Yamaguchi, T. Tachiki, K. E. Gray, W.-K. Kwok.