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Josephson LASER Working at THz Frequencies in Intrinsic Josephson Junctions[1]

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Strong, continuous and monochromatic THz electromagnetic waves with power of order of μW have successfully been generated with the mesa fabricated on the single crystal of high-T_c superconductor $Bi_2Sr_2CaCu_2O_{8+\delta}$ by either ion milling or FIB (Focused Ion Beam) method[2]. The frequency, f, of the radiation depends strongly on the shape and the size of the mesa. In the case of rectangular shape it follows the relation, f=$c/2nw$, where c is the velocity of lihgt in vaccum, n the refractivity of the superconductor and w the width of the mesa(shorter edge dimension), while it only depends on the radius a in the case of cylindrical mesa. Higher harmonics are also observed. Another stringent requirement for the radiation is the *ac*-Josephson effect, which must be fulfilled in each intrinsic junction with the same frequency determined by the equation: $fh = 2eV/N = 2ev_n$, where V is the voltage across the whole junction, N the number of junctions involved in the mesa, v_n the voltage appearing betweeen each junctions, h the Planck constant, e the elementary charge. Since the radiation is monochromatic, v_n must be identical and synchronized coherently in all junctions in the mesa. A simple phenomenological interpretation of this synchronization is that it may occur due to the cavity resonance effect inside the mesa. The peculiar temperature dependence and the anisotropic directivity of radiation power observed experimentally may give a hint to understand the mechanism of such synchronized THz radiation from intrinsic Josephson junctions. We think that nonlinearity to be inherent in the Josephson junction as well as thermal nonequilibrium effect plays a crucial role for the synchronized THz oscillation. A more detailed view for the mechanism based on the experimental results will be presented.

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[2]L. Ozyuzer, *et al.*, Science **318** (2007) 1291, K. Kadowaki, *et al.*, Physica **C468** 634.