Microwave Emission using the Josephson Vortex Flow in Stacked $Bi_2Sr_2CaCu_2O_{8+x}$ Intrinsic Josephson Junctions

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A hybrid system consisting of a Josephson vortex-flow oscillator and a detector using stacked $Bi_2Sr_2CaCu_2O_{8+x}$ intrinsic Josephson junctions was prepared to examine the microwave emission by the Josephson vortex flow. The coupling between the oscillator and the detector was established using an Au film between the two elements. Contrary to a single Josephson junction the fluxon motion in multilayer Josephson junctions does not obey the Lorentz contraction. Although the velocity of vortex lattice matches with the speed of any transverse plasma mode, the velocity matching steps in current-voltage characteristics (IVC) cannot be observed and the velocity of vortex lattice can even exceed the speed of a plasma mode. Such a high-speed vortex motion can induce the Cherenkov radiation. We examined the microwave emission from a Josephson vortex-flow oscillator with the bias corresponding to the range from about 25 GHz to 700 GHz in an external field of 2.5 T. In general, Josephson vortices generated by the magnetic-field component of irradiated microwaves in stacked Josephson junctions reveal the Josephson vortex-flow characteristics in *c*-axis IVC with the suppression of the tunneling critical current. We observed the distinctive change of quasi-particle branches of the detector junctions, which strongly suggested the effect of the microwave emission from the flux-flow oscillator. An increase of the tunneling current was observed near the maximum voltage of each sub-branch corresponding to the critical current. In this regime we observed the pronounced suppression of quasi-particle branches and an increase of the Josephson vortex-flow resistance in the detector. We propose this effect was caused by the Cherenkov microwave emission.

keywords : Josephson vortex lattice, Lorentz contraction, Cherenkov radiation