Theoretical Study on Terahertz Radiations from Nanoscale Intrinsic Josephson Junctions

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Abstract

Electromagnetic waves in terahertz band have many useful applications, but they are not easy to be generated. One possible solution is to make use of intrinsic Josephson junctions (IJJs) from high-T_c superconductor $Bi_2Sr_2CaCu_2O_{8+d}$ (BSCCO) [1]. A novel dynamic state called π-kink state has been found in the IJJs of high-T_c cuprate superconductor, due to the strong inductive coupling at CuO_2 layers with nanometer separation.

In the experimental setups to date, the radiation power is still too weak for practical uses due to the small thickness of BSCCO mesa. In order to overcome this difficulty, we study a long cylindrical BSCCO single crystal embedded in a dielectric material [2]. It turns out that the radiation power reaches its maximum when it equals the dissipation caused by the Josephson plasma, a case of Jacob's law. This condition can be achieved by tuning the dielectric constant of the wrapping material appropriately. The maximal radiation power is given explicitly in terms of material parameters.

Thermal effects during the radiation process are also discussed [3]. We find that the thermal effects play dual roles. On one hand they help synchronize the system and thus enhance the radiation power. On the other hand, they lower the proportion of supercurrent in total injected one, which limits the radiation power.

References

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