Testing odd-frequency Cooper pairing by microwave surface impedance

Y. Asano[a], **A.A. Golubov**[b], Ya. V. Fominov[c], and Y. Tanaka[d]

[a]Department of Applied Physics, Hokkaido University, Sapporo, Japan
[b]Faculty of Science and Technology, University of Twente, Enschede, The Netherlands
[c]L. D. Landau Institute for Theoretical Physics, Moscow, Russia
[d]Department of Applied Physics, Nagoya University, Japan

In superconducting hybrid structures, where translational symmetry or spin-rotation symmetry is broken, superconducting order parameter acquires a component which is odd function of energy. Such odd-frequency pairing state may exist in Ferromagnet/Superconductor (FS) hybrids and in proximity structures involving diffusive normal metal attached to an odd-parity spin-triplet superconductor. Although it is currently assumed that long-range supercurrents observed in recent experiments in SFS junctions are carried by odd-frequency triplet Cooper pairs, there is no direct experimental evidence of odd-frequency pairing so far. In this work we suggest the robust test of odd-frequency pairing. Using the quasiclassical Keldysh-Usadel formalism, we study microwave surface impedance of a hybrid stricture composed from a normal metal film covering a superconductor. In the case when a superconductor has p-wave order parameter symmetry, we predict anomalous features of the impedance which originate from negative superfluid density induced into a normal film. Sign change of the response function is specific to the odd-frequency pairing state. On the basis of obtained results, we propose the method to analyze the spin-symmetry of Cooper pairs in a superconductor and to detect odd-frequency superconductivity.