Nonlinear kinetic inductance of composite superconductors

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Superconductors are characterized by the presence of a kinetic inductance L_k in addition to the ordinary, geometric inductance L_g. While L_g determines the magnetic field energy stored in a superconductor with a current $E_B \sim L_g I^2/2$, L_k is related to the kinetic energy of superconducting electrons $E_k \sim L_k I^2/2$. The dependence of the concentration of superconducting electrons on the temperature T and current I leads to the dependence $L_k(I,T)$, which is used in many applications such as electromagnetic radiation detectors, parametric amplifiers, magnetic field/current detectors.

In my talk I present the results of our works devoted to the study of the $L_k(I,T)$ dependence in two types of composite/hybrid superconductors: superconductor/ferromagnet/normal metal (SFN) [1] and superconductor/normal metal (SN) [2,3]. For the SFN composite in the Fulde-Ferrell state, the unique properties are theoretically predicted: a) the presence of a hysteretic dependence $L_k(I)$, leading to the presence of two states with different L_k values at the same current value; b) strong nonlinearity of L_k both at the depairing current and at a much lower current; c) divergence of L_k not only at the critical temperature, but also at the temperature of the transition to the Fulde-Ferrell state.

For the SN composite consisting of a ‘dirty’ superconductor and a low-resistive normal metal, a range of parameters was found where the $L_k(I)$ dependence has a strongly nonlinear region at a current significantly lower than the depairing current [2,3], which was confirmed in the experiment [2]. Based on the obtained result, a new type of detector (sensor) of single photons (including the gigahertz range) and magnetic field/current was proposed – a sensor on nonlinear kinetic inductance [3].

Bibliography

[1] P.M. Marychev and D.Yu. Vodolazov, Extraordinary kinetic inductance of superconductor/ferromagnet/normal metal thin strip in an Fulde-Ferrell state, Journal of Physics, Condensed Matter 33, 385301 (2021).
[2] M. Yu. Levichev, I. Yu. Pashenkin, N. S. Gusev, and D. Yu. Vodolazov, Finite momentum superconductivity in superconducting hybrids: Orbital mechanism, Phys. Rev. B 108, 094517 (2023).
[3] D. Yu. Водолазов, Nonlinear kinetic inductance sensor, JETP Letters 118, 773 (2023).