ISSN 2713-3079

НАУЧНЫЙ ЖУРНАЛ "GLOBUS"
ТЕХНИЧЕСКИЕ НАУКИ

Том 8, № 1 (42)/2022

Журнал зарегистрирован Федеральной службой по надзору в сфере связи, информационных технологий и массовых коммуникаций.

Художник: Валегин Арсений Петрович
Верстка: Курпатова Ирина Александровна

<u>Контактная информация организационного комитета конференции:</u>
Научный журнал "Globus": Технические науки

Электронная почта: tech@globus-science.ru
Официальный сайт: www.tech.globus-science.ru

Учредитель и издатель ООО «Serenity-Group»

Тираж 200 экз.

Отпечатано в типографии:
В.О., 13-я линия, 20, Санкт-Петербург, Россия, 199178

НАНОТЕХНОЛОГИИ И НАНОМАТЕРИАЛЫ

UDC 537.46.38

THE DYNAMICS OF THE FLUX JUMPS IN SUPERCONDUCTORS

Torakulov Botir Turdiboevich
Teacher
Jizzax State Pedagogical Institute of Uzbekistan
4 Sharof Rashidov, Jizzax 130100, Uzbekistan
Taylanov Nizom Abdurazzakovich
Teacher
Jizzax State Pedagogical Institute of Uzbekistan
4 Sharof Rashidov, Jizzax 130100, Uzbekistan
Nurillaev Orzikul Ubaevich
Teacher
Jizzax Polytechnical Institute
Jizzax 130100, Uzbekistan
Saydayev Obid
Teacher
Jizzax State Pedagogical Institute of Uzbekistan
4 Sharof Rashidov, Jizzax 130100, Uzbekistan

Abstract. In this work, the spatial and temporal distributions of small thermal and electromagnetic perturbations in a plane semi-infinite superconducting sample are studied. Based on a system of equations for temperature, magnetic induction, and vortex motion, a dispersion relation was obtained that determines the growth (or decay) increment of small perturbations. It was shown that, under certain conditions, depending on the values of the parameters of the system, flux jumps of the magnetic flux is observed.

Key words: superconductors, small perturbations, flux jumps, vortex, critical state.

Introduction

The phenomenon of magnetic flux jumps as a result of thermo magnetic instability of the critical state in a superconductor is theoretically investigated [1]. The spatial and temporal distributions of small thermal and electromagnetic perturbations in a plane semi-infinite superconducting sample are studied. Based on the system of equations for temperature, magnetic induction, and vortex motion, a dispersion relation was obtained that determines the growth (or decay) increment of small perturbations. It was shown that, under certain conditions, depending on the values of the parameters of the system, flux jumps of the magnetic flux can be observed.

Basic equations

The distribution of magnetic induction, electric field, and transport current in the superconductor are determined by the following equation

$$rot\vec{B} = \mu_0 \vec{j}. \quad (1)$$

$$rot\vec{E} = \frac{d\vec{B}}{dt}. \quad (2)$$

Accordingly, the temperature distribution in the sample is determined by the heat conduction equation

$$\nu(T)\frac{dT}{dt} = \nabla[\kappa(T)\nabla T] + \vec{j}\vec{E}, \quad (3)$$

where ν and κ are the coefficients of heat capacity and thermal conductivity of the sample, respectively. Addiction $j = j_C(T, B, E)$ is determined by the following critical state equation

$$j = j_C(T, B) + j(E).$$

We will use the Bean model $j_C = j_C(B_e, T) = j_0 - a(T_C - T_0)$, where B_e is the value of the external magnetic induction; $a = \frac{j_0}{T_C - T_0}$; j_0- equilibrium current density, T_0 and T_C- initial and critical temperature of the sample, respectively [1]. In the flow creep mode, the current-voltage characteristic of superconductors is nonlinear, due to the heat-activated motion of vortices [2]. The dependence j (E) in the flow creep mode is described by the expression [3]

$$j = j_C \left[\frac{E}{E_0}\right]^{1/n}, \tag{4}$$

where E_0 is the value of the electric field strength at $j = j_C$; the constant parameter n depends on the pinning mechanisms. In the case when n =1, relation (4) describes a viscous flow [1]. For sufficiently large values of n , the last equality defines Bean's critical state $j \propto j_c$. When 1< n <∞, relation (4) describes the nonlinear creep of the flow [4]. In this case, the differential conductivity is determined by the equality

$$\sigma = \frac{dj}{dE} = \frac{j_C}{nE_B}. \tag{5}$$

The results and discussions

According to equation (5), the differential conductivity increases with increasing background electric field E_B and essentially depends on the value of the rate of change of magnetic induction according to the equality $E_B \propto \dot{B}_E x$. Let's formulate the basic equations describing the dynamics of the development of thermal and electromagnetic disturbances for a simple case - a superconducting flat semi-infinite sample (x >0)

$$\nu \frac{d\theta}{dt} = \kappa \frac{d^2\theta}{dx^2} + j_c \varepsilon, \tag{6}$$

$$\frac{d^2\varepsilon}{dx^2} = \mu_0 \left[\frac{j_c}{nE}\frac{d\varepsilon}{dt} - \frac{dj_c}{dT}\frac{d\theta}{dt}\right]. \tag{7}$$

We represent the solution of system (6), (7) in the form

$$\delta T(x,t) = (T_c - T_0)\theta(z)e^{\frac{\gamma t}{t_0}}, \tag{8}$$

$$\delta E(x,t) = E_c\,\varepsilon(z)e^{\frac{\gamma t}{t_0}}. \tag{9}$$

where γ is the eigenvalue problem to be determined. It can be seen from the last system of equations that the characteristic time for the development of thermal and electromagnetic perturbations of the order of - t_0/γ [5]. We have introduced the following dimensionless parameters and variables

$$\beta = \frac{\mu j_c^2 L^2}{\nu(T_c - T_0)}, \quad t_0 = \frac{\mu j_c L^2}{E_c}, z = \frac{x}{L}, \tau = \frac{t}{t_0}, \; e = \frac{\delta E}{E_c}, t_0 = \frac{\sigma\nu(T_c - T_0)}{j_c^2}, l = \frac{\nu(T_c - T_0)}{\mu_0 j_c^2} \gamma = \frac{1-n}{n}.$$

Let's consider the problem within the adiabatic approximation, when $\tau << 1$, i.e. [5], the diffusion of the magnetic flux occurs faster than the thermal diffusion. Then, we obtain the following equation in the quasi-stationary approximation

$$\frac{d^2\Theta}{dz^2} - z\Theta = 0. \tag{10}$$

Since, when deriving the last equation, we neglected thermal effects, only the electrodynamic boundary should be put in (10)

$$\theta(1,t) = 0, \frac{d\theta(0,t)}{dt} = 0. \tag{11}$$

The stability criterion of the magnetic flux jumps is determined by the values of $\mathrm{Re}\gamma \le 0$. Then, using the second boundary condition $\theta(1) = 0$, we obtain the following equation for determining the parameter γ

$$J_{2/3}(a_n) = J_{-2/3}(a_n)$$

A nontrivial solution of the last equation, taking into account the boundary conditions (10), exists only for certain values

$$a_1 = \rho^{2/3}\gamma.$$

where a_1 are the roots of the characteristic Bessel function. After simple transformations, we obtain the following stability criterion for the flux jumps

$$B_c = \frac{4\pi j_c}{c}\sqrt{\frac{\varkappa(T_c - T_0)}{j_c n B_e}}. \tag{12}$$

It is easy to see that the threshold value of B_c flux jump stability mainly depends on the type of background electric field initiated by a change in external magnetic induction $E_b \approx \dot{B}_e$ [6]. The value of B_c decreases monotonically with increasing of the external magnetic field induction rate in the sample.

Cconclusion

Thus, based on a system of equations for temperature, magnetic induction, and vortex motion, a dispersion relation was obtained that determines the growth (or decay) increment of small perturbations. It was shown that, under certain conditions, depending on the values of the parameters of the system, flux jumps of the magnetic flux are observed.

REFERENCES

1.P. S. Swartz and S. P. Bean, J. Appl. Phys., 39, 4991, 1968.
2.C. P. Bean, Phys. Rev. Lett. 8, 250, 1962; Rev. Mod. Phys., 36, 31, 1964.
3.S. L. Wipf, Cryogenics, 31, 936, 1961.
4.R. G. Mints and A. L. Rakhmanov, Rev. Mod. Phys., 53, 551,1981.
5.N.A. Taylanov J. Mod. Phys. Appl. 2013. Vol. 2 , N. 1, C. 51-58.
6.R. G. Mints and A. L. Rakhmanov, Instabilities in superconductors, Moscow, Nauka, 1984, 362.

UDC 566.6785.0221

MODELING OF THE LABOROTORY WORK "FRANK-HERTZ EXPERIMENT" IN QUANTUM PHYSICS

Urozov Abduxoliq Nurmamatovich
Teacher
Jizzax State Pedagogical Institute of Uzbekistan
4 Sharof Rashidov, Jizzax 130100, Uzbekistan
Bobnazarov Dilshod
Teacher
Jizzax State Pedagogical Institute of Uzbekistan
4 Sharof Rashidov, Jizzax 130100, Uzbekistan
Sherqozieva Mohira Bakhtiyor Qizi
Student
Jizzax State Pedagogical Institute of Uzbekistan
4 Sharof Rashidov, Jizzax 130100, Uzbekistan
Temirova Muqaddas Ulugbek Qizi
Student
Jizzax State Pedagogical Institute of Uzbekistan
4 Sharof Rashidov, Jizzax 130100, Uzbekistan

Abstract. In this article we investigate the problem of modeling laboratory work in quantum physics under the name "The Franc-Hertz experiment". The dependence of the light intensity and frequency on the anode voltage is investigated. There is a known voltage value between the anode and the photocathode, where the photocurrent is zero. The process of formation of the photoelectric effect at a given voltage as a result of a change in the parameter U was analyzed from the point of view of modeling.

Key words: information technology, quantum physics, modeling.