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Estimation of electromagnetic pulse power during magnetic microcumulation in a thin superconducting film

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The operation of a magnetocumulative generator is accompanied by the appearance of parasitic electromagnetic radiation. It is presumed that the compressed coil acts as a loop antenna [1]. The article [2] considers the case of microscopic cumulation of a trapped magnetic field in a thin YBaCuO film of a type II superconductor. As a result of microcumulation, superconducting properties locally disappear, leading to the fast decay of the accumulated field. According to Maxwell's equations, the process of fast magnetic field vanishing should be accompanied by the appearance of an electromagnetic pulse. This raises the question: can this pulse be detected?

The difficulty in estimating the pulse power of a decaying magnetic dipole $\boldsymbol{m}$ is a negligible coefficient $\mu_0/(6\pi\cdot c^3)$ before $|\ddot{\boldsymbol{m}}|^2$, where μ_0 is the magnetic constant and c is the light velocity. In models for the power estimation, functions describing the vanishing moment should be chosen such that the second derivative approaches infinity at a certain point. The microcumulation parameters λ_{eff}, j_{1S} for the film with the highest critical current density are taken from paper [2]. The time of complete decay of $\boldsymbol{m}$ depends on the dynamics of microcumulation and the subsequent increase in temperature. The beginning of the decay process is determined by the Fermi time, which is about 10^{-15} s. Under such conditions, $\boldsymbol{m}$ is estimated to vanish over a time interval between 0÷1.5 ps and 0÷6.5 ps. The value of the $\boldsymbol{m}$ before the decay is $11.8\cdot10^{-12}$ $A\cdot m^2$. The decay process was modeled using the function arcsech(kt) on the interval [0,1] in its logarithmic representation, where k is the scaling factor. Its second derivative tends to infinity at zero. We estimate the average value of $\ddot{\boldsymbol{m}}$ where it is steepest over the [0, 0.25] segment of the boundary time intervals. The results obtained are presented in Table 1.

Table 1. Characterization of magnetic dipole radiation during the microcumulation

$\boldsymbol{m}$ decay time, s	irradiation time, s	$\lvert\ddot{\boldsymbol{m}}\rvert$, $A\cdot m^2/s^2$	frequency band, Hz	power, W
$1.5\cdot10^{-12}$	$0.375\cdot10^{-12}$	$1.73\cdot10^{16}$	$2.66\cdot10^{12}$	$0.74\cdot10^{-3}$
$6.5\cdot10^{-12}$	$1.625\cdot10^{-12}$	$4\cdot10^{15}$	$0.615\cdot10^{12}$	$0.04\cdot10^{-3}$

Detection of repetitive picosecond pulses of electric dipole radiation, whose coefficient is c^2 times greater, is a rather difficult problem [3]. Potentially, to detect randomly generated picosecond milliwatt pulses, it is possible to apply the technology used to detect single photons with a superconducting device [4].

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