brackets in (4) then vanishes, and the first term is replaced by $\ln(q_0/q_{min})^2$.

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FEASIBILITY OF INVESTIGATING A PINCH DISCHARGE BY USING ITS INTRINSIC STIMULATED EMISSION

V. M. Likhachev, M. S. Rabinovich, and V. M. Sutovskii
P. N. Lebedev Physics Institute, USSR Academy of Sciences
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The existence of negative-temperature states in a high-temperature plasma of a strong-current pinch discharge has been demonstrated by us in an earlier paper [1], where stimulated emission was generated for the first time in a plasma of such a discharge. We report here the use of this phenomenon to investigate the cumulation of a pinch discharge. To this end we measured the time correlation between the stimulated-emission pulse and the current pulse at the instant of discharge cumulation.

The discharge was produced in a quartz tube of 40 mm inside diameter and 1 m length. The electrodes were tantalum rings of 40 mm diameter. The energy sources were 0.01, 0.1, and 0.4 μF capacitors charged to as much as 45 kV. The maximum discharge current was 20 kA at a discharge duration 2 μsec. The current density at the instant of cumulation reached 50 - 75 kA/cm^2. To observe the stimulated emission pulse, confocal dielectric-coated mirrors designed for the emission-wavelength (λ = 4500 - 5000 Å) were mounted at the ends of the discharge chamber. The working gas was spectrally pure argon. To facilitate probe measurements, the discharge-chamber diameter was increased (to 40 mm). The optimal pressures for generation were then appreciably lower than in the cited investigation [1], amounting to 2 x 10^{-3} - 5 x 10^{-4} mm Hg (see Fig. 1).

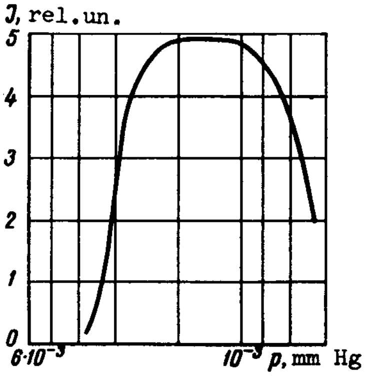

Fig. 1. Stimulated-emission intensity vs. initial pressure.

To establish the time correlation between the generation pulse and the current at the instant of cumulation, measurements were made with a Rogowski loop placed in a glass tube bent in the form of a ring, with inside and outside diameters 7 and 12 mm. It follows from such measurements that at the instant of cumulation the current is concentrated in the axial part of the discharge chamber, and there is none in the region adjacent to the wall. Generation is observed along the discharge axis only in the narrow region that is not cut off by the internal loop. A second Rogowski loop was used to measure the total current in the discharge circuit. The currents were recorded with a double-beam oscilloscope. The presence of a Rogowski loop in the center of the discharge chamber naturally affects the generation conditions adversely. Therefore the probe was removed from the central part of the chamber when the generation pulse was recorded. It follows from the presented oscillograms (Fig. 2) that the maximum of the generation pulse coincides with the instant of cumulation of the current. It must also be noted that generation occurs not only during the instant of maximum contraction of the plasma pinch, but also as the plasma front moves during the stage immediately preceding the discharge cumulation. This is evidenced by a bright generation spot, whose dimensions exceed the cumulation region, and whose diameter is about half that of the discharge chamber. However, the emission maximum coincides, within the limits of measurement accuracy, with the maximum of the current.

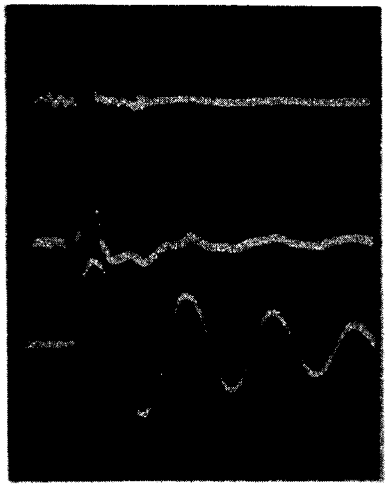

Fig. 2. Oscillograms (top to bottom) of the generation pulse, the pulse from the Rogowski loop in the center of the discharge chamber, and the total current in the circuit.

We did not investigate in detail the energy characteristics of the stimulated emission, but it was noted that generation takes place in a tube of so large a diameter only at sufficiently large currents, ~2 kA. Thus, when a 0.01 μF capacitor was used, no generation was observed at all in a wide range of voltages. At 0.1 μF, generation was observed, but was very weak. Intense generation occurred when a 0.4 μF capacitor was used, charged to voltages up to 45 kV.

The experiments show that the characteristics of stimulated emission depend strongly on the discharge conditions. Therefore an investigation of the character of the generation can serve as an additional means of pinch-discharge diagnostics and of studying nonequilibrium plasma contraction and relaxation processes. A similar picture should be observed also in other plasma installations, for example in a θ pinch or when a radial convergent shock wave is produced in installations for turbulent plasma heating, etc.

The presence of intrinsic stimulated emission in a pinch discharge gives grounds for hoping that at sufficiently high generation power this emission can be used also to determine the plasma parameters by means of incoherent scattering by ions and electrons, by nonlinear interaction with the plasma, etc. The scheme for a possible experiment is similar to that for the classical experiments on plasma diagnostics with lasers, except that the external coherent-light source is replaced by the intrinsci stimulated emission of the pinch-discharge plasma. This method makes it possible to determine the plasma-pinch parameters directly during the instant of generation.

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CRITICAL TEMPERATURE OF SMALL SUPERCONDUCTORS

E. A. Shapoval
Physics Department, Moscow State University
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It is known [1] that the critical temperature of sufficiently small superconductors (non-annealed films) increases with decreasing dimensions. Attempts were made to explain this effect theoretically. Kirzhnits and Maksimov [2] related the growth of the transition temperature with an increase of the effective constant for the interaction between the electrons in the surface layer, due to the Rayleigh waves. Kresin and Tavger [3] attempted to attribute this effect to quantization of the transverse momentum of the electrons in thin films, a quantization which is in fact nonexistent by virtue of the diffuse reflections of the electrons from the surfaces of even very "good" films.

We shall show below that the growth of the critical temperature of small samples can be explained within the framework of the BCS superconductivity theory without making use of any new electron-pairing mechanism whatsoever.

The author has shown in [4] that the critical temperature (and to an equal extent also the temperature dependence of the ordering parameter Δ) does not depend on the shape or dimensions of the sample. The limitation mentioned in that paper (sample dimensions larger than v_F/ω_D), connected with the fact that momentum cutoff in Bardeen's four-fermion Hamiltonian leads to a spatial smearing of the interaction at distances $\sim v_F/\omega_D$ (see, e.g., [5]), is in fact insiginificant. Indeed, if we start from the more realistic Frohlich Hamiltonian and use the method developed by Eliashberg [6], we can show that the cutoff in the equation

$$\Delta(r) = |\lambda| \sum_{\omega} F_{\omega}(r, r) \tag{1}$$

should be carried out during the calculation not with respect to the momenta (or energies), but with respect to the frequencies at $\omega \sim \omega_D^*$. This means that the interaction of the electrons via the phonon field, which is responsible for the superconductivity, is local and not instantaneous, this being connected with the low propagation velocity of the lattice excitations. Indeed, the lifetime of the virtual excitation $\tau \sim 1/\omega_D$ is relatively large, but during that time the excitation can propagate only over a distance on the order of the lattice constant $a \sim \tau c$.

The transition temperature can be determined by finding the maximum temperature at which a nontrivial solution exists for the integral equation

$$\Delta(r) = |\lambda| T \sum_{|\omega|<\omega_D} \int G_{\omega}(r, r') G_{-\omega}(r, r') \Delta(r')\, dr'. \tag{2}$$