INFLUENCE OF THE SKIN EFFECT ON THE OPTICAL PROPERTIES OF A MICROWAVE DISCHARGE

A. I. Maksimov
Institute of Chemical Physics, USSR Academy of Sciences
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We have investigated the dependence of the intensity of the spectral lines on the power of a microwave discharge in helium. The discharge was ignited in quartz tubes using the microwave chamber designed by V. S. Nikol'skii [1], fed from a magnetron operating in the continuous mode at 3000 Mc. The power absorbed in the discharge was measured by usual microwave methods. The spectrum of the radiation emerging from the end of the tube was registered with an ISP-51 spectrograph equipped with an FEP-1 photographic attachment. Figure 1 shows the dependence of the intensity of the spectral lines 4713 Å (a) and 5016 Å (b) on the power of the discharge in helium. The numbers 1, 2, 3, and 4 at the curves correspond to pressures 0.33, 0.53, 1.13, and 2.2 mm Hg. The discharge tube employed (o.d = 1.7 cm) had internal windows which bounded a discharge zone 3 cm long and which cut out the light flux from the axial zone of the plasma. A noteworthy fact was that the same dependence was observed for lines with essentially different self absorption in the discharge. At low power, the intensity variation was practically linear, but this was followed by deviation from linearity, and at 0.54 mm Hg a clearly pronounced intensity maximum was observed, corresponding to a power of 40 - 45 W. It must be noted that the discharge brightness observed visually through the side

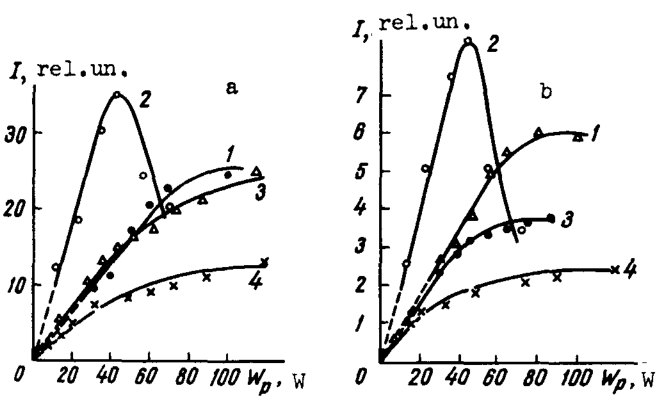

Fig. 1.

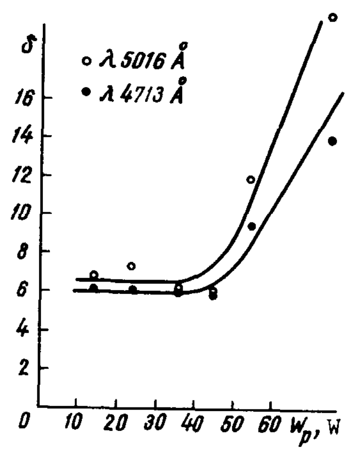

Fig. 2

wall continued to increase at the same time. These intensity maxima were not observed when we used a discharge tube that made it possible to register radiation from the entire cross section. The described effect can be explained by assuming that under these conditions the magnitude of the skin layer is close to the radius of the discharge tube. An estimate shows that for this purpose it is necessary that the electron concentration be smaller than 10^{12}, a perfectly realistic requirement for the conditions of this experiment.

The weakening of the field in the center of the discharge by the skin effect can lead to a decrease in the average energy of the electrons in this region, accompanied by attenuation of the radiation intensity on the axis while the overall intensity increases. The maximum of the intensity should shift in this case to the peripheral zone. To check on this assumption, we made additional measurements with a narrower radiation beam at a pressure (0.53 mm Hg) corresponding to the most pronounced maximum. We obtained the ratios of the radiation intensities (δ) of the annular and axial zones of the plasma. This ratio is shown in Fig. 2 as a function of the discharge power. At 45 watts, corresponding to the start of the decrease of the curves on Fig. 1 at microwave power, δ begins to decrease rapidly, showing that the maximum of the intensity shifts to the peripheral region and confirming the foregoing assumption.

[1] V. S. Nikol'skii, Byulleten' izobretenii (Bulletin of Inventions) No. 22 (1961).

SELF FOCUSING OF WAVE BEAMS IN NONLINEAR MEDIA

V. I. Talanov
Scientific Research Radio Physics Institute, Gor'kii
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References [1,2] contain calculations of cylindrical self-maintaining waveguide channels (2- and 3-dimensional) in an isotropic nonlinear dielectric with wave number $k_n = k[\epsilon(E_0^2)]^{1/2}$ ($k = (\omega/c)n_0$ is the wave number as $E_0 \to 0$, and E_0 is the field amplitude). We discuss below certain features of paraxial wave beams in such a medium in the case of weak nonlinearity of ϵ: [1)]

$$\epsilon = 1 + \epsilon' E_0^2; \quad \epsilon' E_0^2 \ll 1; \quad \epsilon' > 0 \tag{1}$$

Under the assumptions customarily made in quasi-optics concerning the character of the wave beam [2], which make it possible to disregard the polarization effect and the longitudinal diffusion in the ray amplitude for E_0 and the slowly varying part φ of the phase beam $E = E_0 \exp(ik\tilde{z} - i\varphi + i\omega t)$, we obtain the following equations (in dimensionless coordinates $k\tilde{x}$, $k\tilde{y}$, $k\tilde{z}$)

$$\partial E_0^2/\partial z = -\mathrm{div}_\perp(E_0^2 \nabla_\perp \varphi); \quad 2\varphi_z' + (\nabla_\perp \varphi)^2 = \epsilon_{eff} - 1 \tag{2}$$

$$\epsilon_{eff} = \epsilon(E_0^2) + (\Delta_\perp E_0/E_0) \tag{3}$$

which are equivalent to the equation for the transverse diffusion of the ray amplitude of the field [3]. A consequence of (2) is the following equation for paraxial rays

$$\ddot{\vec{r}}_\perp = \frac{1}{2}\nabla_\perp \epsilon_{eff} \tag{4}$$