

DETERMINATION OF THE TEMPERATURE AND CONCENTRATION OF ELECTRONS IN AN ARC PLASMA FROM THOMSON SCATTERING OF LASER RADIATION

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Abstract**Full Text**

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PHYSICS

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DETERMINATION OF THE TEMPERATURE AND CONCENTRATION OF ELECTRONS IN AN ARC PLASMA FROM THOMSON SCATTERING OF LASER RADIATION*(Presented by Academician B. P. Konstantinov, 16 VII 1965)*

From theoretical (¹⁻³) and experimental (⁴⁻⁵) works it is known that, from radiation scattered in a plasma, one can determine the temperature and concentration of electrons. We used this method to study a dc arc in a magnetic field.

The layout of the apparatus used is shown in Fig. 1. A beam of plane-polarized light ($\lambda = 6943 \text{ \AA}$) from a ruby laser, with an energy of 25 J, passed through a system of lenses L_1, L_2 , diaphragms D_1, D_2, D_3 , and windows O_1, O_2 , and was focused at the center of the discharge tube. The radiation scattered by plasma electrons was observed at a right angle to the direction of the incident light ($\theta = 90^\circ$). This radiation, by means of a system of lenses L_3 , was collected from a volume 7 mm long and 0.6 mm in diameter, within a solid angle $\Delta\Omega = 1/32$ steradian, and, after passing through prism P , which rotated the image by 90° , was directed to the entrance slit of a double monochromator M_1, M_2 . Recording of the radiation was carried out by means of an PM_1, PM_2 photomultiplier and an S-19A oscilloscope.

Fig. 1. Layout of the apparatus

An arc discharge in a magnetic field, analogous to that investigated earlier (⁷), took place in a glass tube 50 mm in diameter. The distance between the heated cathode and the anode was 280 mm. The plasma volume under investigation was at the center of the discharge, at a distance of 140 mm from the cathode. The discharge current flowed through the tube for several tenths of a second. The laser-radiation pulse occurred in the middle of this time interval. The duration of the laser pulse was $\Delta t = 0.5$ msec. The magnetic field was directed

Fig. 2. Contour of radiation scattered by plasma electrons (1) and contour of parasitically scattered light (2)

Figure 2: Fig. 2. Contour of radiation scattered by plasma electrons (1) and contour of parasitically scattered light (2)

along the axis of the discharge and was about 800 oersted. The pressure of the helium flowing through the tube was $p = 0.2$ mm Hg. The deflection on the oscilloscope screen due to scattering of light by plasma electrons was found from the relation

$$I_p = I - I_{pl} - I_{par},$$

where I is the deflection in the presence of plasma and a laser pulse, I_{par} is the deflection corresponding to the laser (parasitic scattering) pulse in the absence of plasma, and I_{pl} is the deflection corresponding to the glow of the plasma.

To verify that the measured quantity was caused by scattering of laser light by plasma electrons, a quartz plate rotating the plane of polarization by 90° was used. Indeed, when this plate was inserted between the laser and the first lens L_1 , the reading I_p was absent.

Calibration of the entire measuring system as a whole was carried out by Rayleigh scattering. For this purpose the discharge tube was filled with helium and readings corresponding to scattering by the gas at a pressure of about 1 atm were recorded. With such calibration, errors in measuring a number of quantities that are difficult to measure—such as the absolute value of the laser energy, the aperture ratio, the sensitivity of the receiver, etc.—are eliminated. This made it possible, using the Rayleigh scattering cross section known from theory⁽⁸⁾, to determine the electron concentration reliably. The spectral width of the monochromator slits was 10 \AA .

Fig. 2. Contour of the radiation scattered by plasma electrons (1) and contour of the parasitically scattered light (2)

The results of the experiment are shown in Fig. 2. Here 2 is the contour corresponding to parasitically scattered light. At a laser wavelength $\lambda = 6943 \text{ \AA}$, the ratio $I_{par}/I_p = 30$.

Curve 1 is drawn through the experimental points corresponding to the contour of the scattered light (I_p). The scatter of the experimental points, characterized by the arithmetic mean ratio, is shown by vertical segments.

The electron temperature was determined from the half-width of the scattered-light contour, taking into account the width of the instrumental contour⁽⁹⁾, and for $\Delta\lambda = 43 \text{ \AA}$ amounted to $T_e = 1.8 \text{ eV}$. The electron concentration was determined as $n_e = 2.5 \cdot 10^{13} \text{ cm}^{-3}$. (The value of the concentration of charged particles determined by the probe method proved to be of the same order.) The

parameter α ⁽³⁾, calculated from these data for T_e and n_e , is equal to 0.04, i.e. $\alpha \ll 1$, and we are indeed dealing with Thomson scattering by plasma electrons.

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CITED LITERATURE

1. E. E. Salpeter, *Phys. Rev.*, **120**, 1528 (1960).
2. M. N. Rosenblut, N. Rostoker, *Phys. Fluids*, **5**, 776 (1962).
3. E. T. Gerry, R. M. Patrick, *Phys. Fluids*, **8**, 208 (1965).
4. W. E. R. Davies, S. A. Ramsden, *Phys. Letters*, **8**, 179 (1964).
5. H. J. Kunze, E. Fünfer et al., *Phys. Letters*, **11**, 42 (1964).
6. V. Ascoli-Bartoli, J. Katzenstein, L. Lovisetto, *Nature*, **204**, 672 (1964).
7. V. E. Golant, M. V. Krivosheev, V. E. Privalov, *ZhTF*, **34**, 953 (1964).
8. A. Sommerfeld, *Atomic Structure and Spectra*, 1, 1956.
9. S. G. Rautian, *UFN*, **66**, 475 (1958).

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