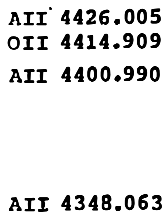

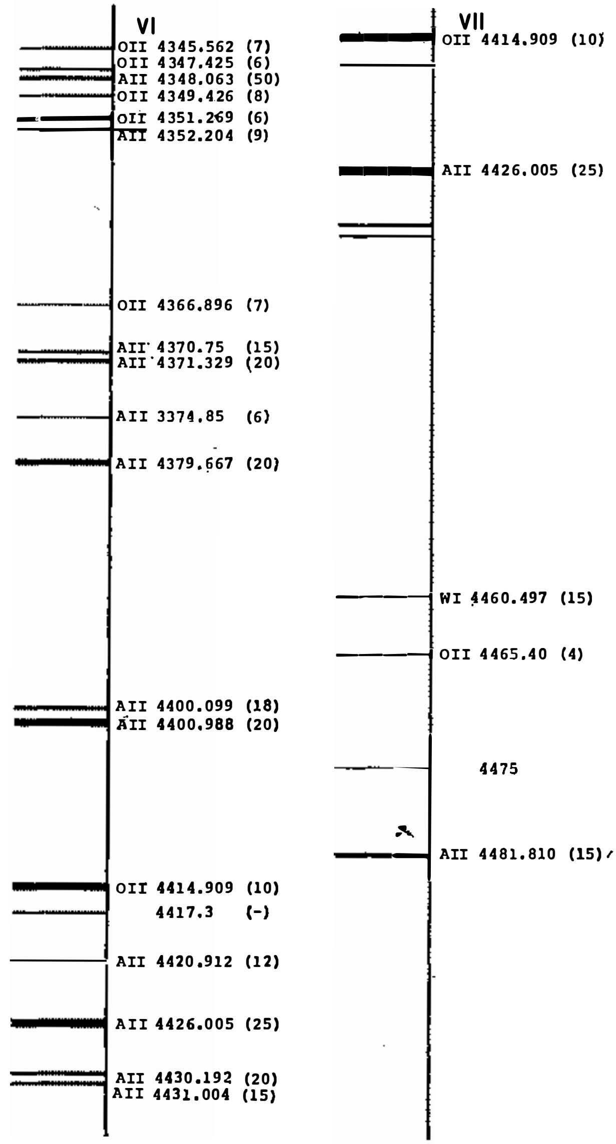

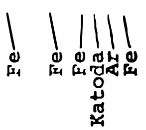

Fig. 2. Optical spectrum of the pulsed discharge ($U = 800$V, $B = 600$ Gs, $p = 5 \cdot 10^{-4}$ torr).

Fig. 3. The reproduced optical spectrum obtained under the above conditions.

3.19 Scattered spectra of the ion feature

M. PLATIŠA, *Institute of Physics, Beograd, Yugoslavia*

Light scattered by free electrons from a plasma can be used as a diagnostic technique. Because of very small Thomson scattering cross section only the development of powerful pulsed lasers has made this technique a basic tool in plasma physics.

The shape of the scattered spectrum is determined by the parameter introduced by Salpeter[1]:

$$\alpha = \frac{1}{KD} = \frac{\lambda_0}{4\pi D \sin\frac{\theta}{2}}, \tag{1}$$

where λ_0 is the wavelength of the incident light, D is the Debye radius and θ is the angle between the incident and scattered light, When $\alpha \gg 1$ the scattered spectrum is modified by co-operative interaction between the ions and electrons and consists of a central or ion feature, whose width is of the order of the Doppler shift for ion thermal velocities, flanked by a pair weak satellites, corresponding to scattering from longitudal electrostatic oscillations in plasma. The profile of the central line is determined by

$$\beta = \sqrt{\frac{\alpha^2}{1+\alpha^2} \frac{zT_e}{T_i}}.$$

For $\beta \ll 1$ the shape of the ion line has a Gaussian profile. For an isothermal hydrogen plasma, $z = T_e/T_i = 1$ we have $\beta < 1$, the line shape is then characterized by a profile with a central minimum. If the ion temperature T_i is lower than electron temperature, as well as $\alpha \gg 1$, we may have $\beta \gg 1$ and the central line is then split into two resonance lines. These sharp resonance lines represent the so-called positive ion oscillations.

In general, the measured profile of the scattered spectrum is compared with the theoretical curves calculated for a certain temperature and different values either α or β. The calculated shape, which best fits the experimental data, is then taken as a real profile of the scattered spectrum and used for the evaluation of all obtainable parameters. For Thomson domain ($\alpha \ll 1$) the electron spectra have been calculated by Kegel[2]. According to Salpeter's theory, for the co-operative domain, the scattered spectra for the ion feature of an isothermical hydrogen plasma have been calculated by Platiša[3]. In this calculation the absence of a magnetic field and no electron drift relative to ions were assumed. A typical scattering spectrum for $\beta < 1$ is given in Fig. 1. By comparing experimental spectra with the theoretical profiles, ion temperature and electron density can be determined. From these calculated normalised intensity distributions other temperatures may be covered for the same β by generating a new distribution using $y = y_0$, where y is defined as

$$\Delta\omega / K\sqrt{\frac{2kT_i}{M}} \quad \text{or:}$$

$$\Delta\lambda = 4.15 \times 10^{-3} \cdot \Delta\lambda_0 \cdot \sqrt{T}, \tag{2}$$

where $\Delta\lambda_0$ is the calculated value. In order to find the temperature for an experimentally spectrum at any other of observation θ for a given β with the condition y=constant one easily obtains[4]:

$$T = T_0 \frac{\Delta\lambda^2}{\Delta\lambda_0^2} \cdot \frac{\sin^2\frac{\theta_0}{2}}{\sin^2\frac{\theta}{2}}, \tag{3}$$

and electron density:

$$n = n_0 \frac{\Delta\lambda^2}{\Delta\lambda_0^2} \cdot \frac{\sin^2 \frac{\theta_0}{2}}{\sin^2 \frac{\theta}{2}} . \tag{4}$$

Thus if one plots the normalized intensity of the scattered spectra against θ then, for the same β but different temperatures, the same shape will arise with varying horizontal displacements. Only the shape of the line is important and the curves can be shifted horizontally either left or right. From the shape of the spectrum

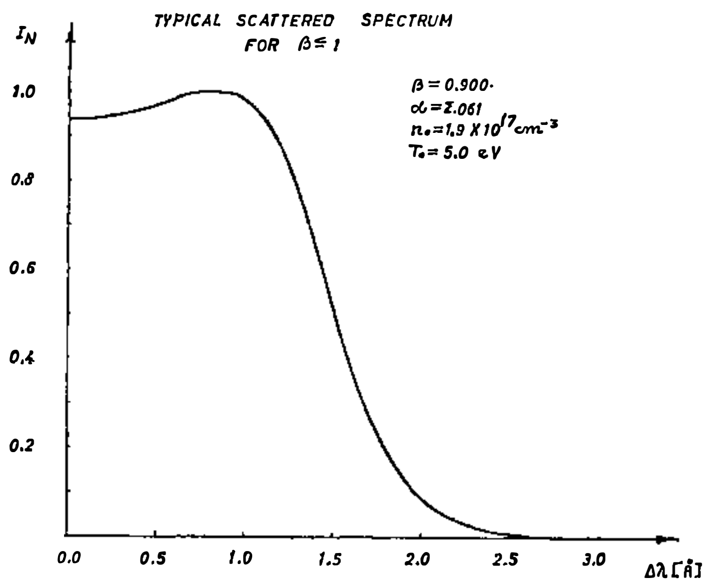

Fig. 1

one determines the scattering parameter β. The ion temperature and electron density can be obtained from the difference of the equivalent points of the calculated spectrum for the temperature T_0, and the measured spectrum according the equaions (3) and (4).

References

1) E. E. Salpeter, Phys. Rev., **120** (1960) 1528;
2) W. H. Kegel, Institut für Plasmaphysik, Report IPPG/34 (1965);
3) M. Platiša, Institute of Physics, Beograd (1970);
4) M. Platiša, Ph. D. Thesis, University of Liverpool (1970).