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"EXPERIMENTAL AND THEORETICAL INVESTIGATION OF PLASMA RADIATION"

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I. EXPERIMENTAL PROGRAM

I. 1. Measurement of the Stark Broadening of Neutral Atom Resonance Lines

From a direct comparison of the profiles of the optically thick, Stark-broadened emission lines AIλ1048 Å and AIλ1067 Å with those of Lyman -α and Lyman -β, we have determined the product of the damping constant (for Stark Broadening) and the oscillator strength for each of the argon lines.[1] Our values are

$$\left(\frac{\Gamma}{N_e} \cdot f\right)_{1048} = 1.2 \pm 0.2 \times 10^{-20}$$

and

$$\left(\frac{\Gamma}{N_e} \cdot f\right)_{1067} = 0.3 \pm 0.04 \times 10^{-20}$$

where N_e is electron density in cm^{-3}.

For our plasma conditions ($N_e = 1.6 \pm 0.2 \times 10^{17}$ cm^{-3}, kT_e = 1.2 ± 0.03 eV) this method of measurement is very insensitive to both N_e and T_e, such that the error on the products $(\frac{\Gamma}{Ne}\ f)$ is due almost entirely to experimental uncertainty in the vacuum ultra-violet intensity measurements (relative only) and to uncertainty in the calculated values of the broadening constants for the hydrogen Lyman lines.

The truncated profiles of the lines L_α and L_β were also used to measure temperature. From the half-widths of these lines we determined the hydrogen ground state density. Then, using the measured electron density (from the half-width of H_β) and applying the Saha equation we deduced a temperature

$$kT_e \text{ (Lyman)} = 1.27 \pm 0.06 \text{ eV.}$$

As anticipated this temperature which relies only on relative intensity measurements, agrees very well with the temperatue determined from the visible argon lines AI λ 6965 Å and AII λ 4806 Å,

$$kT_e \text{ (Argon visible)} = 1.2 \pm 0.03 \text{ eV.}$$

I. 2. Measurement of the Stark Broadening Parameters of Visible and Ultra-Violet Lines

A re-analysis of our measurements on the broadening of the neutral helium lines λ 3889 Å and λ 5016 Å, has shown that there is very good agreement between measured and calculated values for both the width and shift of each of these lines,[2] provided that for the line λ 5016 Å we allow for Debye shielding. In this re-analysis numerical fitting techniques were used and proper allowance was made for the interference. of the line HeI λ 4922 Å with H_β,which was used to measure electron density. We have also observed emission in the forbidden line HeI λ 5042 Å (2'S - 3'D) in these measurements.

Using a 2m grazing incidence monochromator we have recorded profiles of the ionized helium resonance line HeII λ 304 Å in the emission from our T-tube source. This line is very optically thick under our plasma conditions ($N_e \sim 3 \times 10^{17}$ cm^{-3}, kTe ∿ 4eV) and shows the typical truncated profile. The half-width of the profile ($\Delta\lambda_{1/2} \sim 0.4$ Å appears to be in agreement with the calculated broadening caused by ions and electrons in the plasma[3] and the significant blue shift (∿ 0.05 ± 0.01 Å) can be explained in terms of the polarization of the plasma in the vicinity of a positively charged emitter.[4]

Little progress has been possible on the measurement of the broadening of argon ion lines because of the unavailability of the graduate research assistant caused by the present Draft Regulations.

I. 3. Collective Bremsstrahling from Collision Free Shock Waves

Using our new Θ-pinch apparatus with hydrogen as the filling gas we have found strong emission of far infra-red radiation (0.1 mm < λ < 4mm). This emission begins a little before the time the gradient of B - the magnetic piston, is steepest and gets more intense as the initial filling pressure is decreased. These observations indicate that the emission occurs in the current layer and is probably not caused by collisions. The electron density of the preheater plasma was $\sim 3 \times 10^{13}$ cm^{-3} at the time the main bank is fired and there was an anti-parallel bias field of about 400 gauss.

Initial attempts to obtain the spectral distribution of this far infra-red radiation suggest that there may be a peak at $\lambda \sim 0.7$ mm, but this is very dependent on the relative sensitivity of the far infra-red system which unfortunately has a strong wavelength dependence.

II. THEORETICAL PROGRAM

The calculations of ionized helium lines in the Lyman, Balmer and Paschen series were continued and and are now almost completed. A journal paper on these lines is being written by Dr. Kepple, and the tables obtained will be made available as a technical report.

In collaboration with Dr. Bely from Nice Observatory we carried through the very first fully quantum-mechanical calculation of any impact broadened line (the MgII resonance line). A paper reporting on the results will appear shortly in Physical Review. This paper discusses also the question which of the various classical-path approximations are reasonably good, which not.

References:

1. "Measurement of the Stark broadening for the Neutral Resonance lines AI 1048 Å and AI 1067 Å", G. A. Moo-Young, J. R. Greig and H. R. Griem. To be presented at A.P.S. - D.P.P. meeting November 1969.

2. "On the Stark Broadening of Two Neutral Helium Lines in Plasmas", J. R. Greig and L. A. Jones, submitted to Physical Review (October 1969).

3. "Measurement of the Stark Broadening of HeII Lyman-Alpha", L. A. Jones, T. Oda and J. R. Greig. To be presented at A.P.S. - D.P.P. meeting November 1969.

4. "Observation of a Plasma Polarization Shift for the Resonance Line Of Ionized Helium", J. R. Greig, H. R. Griem, L. A. Jones and T. Oda. To Be submitted to Physical Review Letters (October 1969).