ABSOLUTE INTENSITY CALIBRATION AT 26 Å BY BRANCHING RATIOS TO THE VISIBLE

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The technique for absolute calibration using the branching ratio of two transitions which have a common upper level but widely separated energies has been employed and described by Griffin and McWhirter (1961).

Using the plasma produced by irradiation of a carbon target with a 1 GW, 6 nsec duration, neodymium laser pulse, we have been able to calibrate a grazing incidence spectrograph at the wavelength (25.83 Å) of the 7–1 transition in C VI by direct comparison with the intensity of the 7–6 (3434 Å) transition emitted from the same ions in the plasma. The spectrum from a similar carbon plasma has been described by Boland *et al.* (1968) and in several ways is ideal for this type of measurement.

Highly ionised atoms are readily produced which emit lines simultaneously in the visible and soft X-ray region. The upper levels $n \gtrsim 7$ are in approximate local thermodynamic equilibrium with the continuum, a consequence of the very high density in the expanding plasma ($\sim 3 \times 10^{18}$ at 1 mm from the target surface). The plasma ions are well-defined in space and time (Irons *et al.*, 1972) and are sufficiently long-lived against recombination for the relative ion populations to remain almost constant during the line intensity measurements. In the present case also the lines originate from substates which are populated according to their statistical weights.

A further requirement in using the branching ratio technique is that the plasma has to be optically thin to the line radiation. This was verified in three ways:

(i) The ratio of line intensities as a function of distance away from the target surface, i.e. as a function of decreasing density, was constant as the density changed by two orders of magnitude, indicating that the lines are optically thin.

(ii) The intensity of the short wavelength line relative to the free-bound continuum was in agreement with theoretical expectations for a line which is optically thin and which originates from a state above the thermal limit.

(iii) The criterion for optical thinness (Cooper, 1966) is satisfied assuming for the short wavelength line, a thermal Doppler profile with ion temperature equal to the measured electron temperature. The profile however was observed to have a complex shifted component due to the plasma motion (Irons *et al.*, 1972) and the criterion for optical thinness is relaxed considerably from that of Cooper (1966). The long wavelength line has a Stark width of ~ 13 Å, and well satisfied the criterion for optical transparency.

For the experiment the plasma was viewed at right angles to the target normal, 1 mm from the target surface. The long wavelength transition was recorded photoelectrically with a $1\frac{1}{2}$ m Ebert Monochromator calibrated for absolute intensity. As yet only a preliminary value for the calibration is available, but is in sensible

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agreement with oxygen kα photon flux measurements at nearly the same wavelength. The calibration can be extended to other wavelengths in the range $10 \rightarrow 100$ Å by using elements other than carbon as the target material and to wavelengths longer. than 100 Å by using transitions onto bound states other than the ground state.

References

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