

## SECTION 3 — PHENOMENA IN PLASMAS

## 3.1 Déplacement des raies de l'atome CsI dû à l'action simultanée d'un champ électrique et d'un champ magnétique constants

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## 3.2 A study of the Stark broadening of isolated ion lines in plasma

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The GBKO theory, based on the straight classical perturber path approximation, proved highly successful in predicting widths and shifts of isolated lines of neutrals. However, the experimental half-widths for singly ionized atoms other than helium yielded values 2 to 10 times larger<sup>1,2)</sup> than theoretically predicted<sup>3)</sup>. In this paper, the advantages and limitations of Griem's semiempirical approach<sup>4)</sup> for evaluation of half-widths of isolated ion lines, caused by electron impact, will be discussed.

Because of the lack of reliable excitation functions for electron-atom collisions, Griem was extensively making use of the semiempirical Gaunt factors (proposed by Van Regemorter and Seaton), extrapolating from below the excitation thresholds (elastic collisions).

Griem derived semiclassical analytic expression for the half-width of an isolated ion line:

$$W_{se} \approx 8 \left( \frac{\pi}{3} \right)^{3/2} \frac{\hbar}{ma_0} N \left( \frac{E_H}{kT} \right)^{1/2} \cdot \sum \left[ |\langle i' | r | i \rangle|^2 \bar{g}_{se} \left( \frac{\bar{E}}{|\Delta E_{i' i}|} \right) + |\langle f' | r | f \rangle|^2 \bar{g}_{se} \left( \frac{\bar{E}}{|\Delta E_{f' f}|} \right) \right], \quad (1)$$

where the effective Gaunt factor is denoted by  $g_{se}$  whose formula can be simplified further if nearest perturbing levels are dominant ones, as it is usually the case. One obtains

$$W_{se} \approx 8 \left( \frac{\pi}{3} \right)^{3/2} \frac{\hbar}{ma_0} N \left( \frac{E_H}{kT} \right)^{1/2} \left[ \langle i | r^2 | i \rangle \bar{g}_{se} \left( \frac{3kT}{2|\Delta E_i|} \right) + \langle f | r^2 | f \rangle \bar{g}_{se} \left( \frac{3kT}{2|\Delta E_f|} \right) \right], \quad (2)$$

$$\text{with } E = \bar{E}_{kin} = \frac{1}{2} mv^2.$$

The applicability of these formulas (Eq. 1 when perturbing levels are treated individually and Eq. 2 when lumped together) is illustrated in Fig. 1, where ratios of measured to calculated line half widths of C1 II are given.

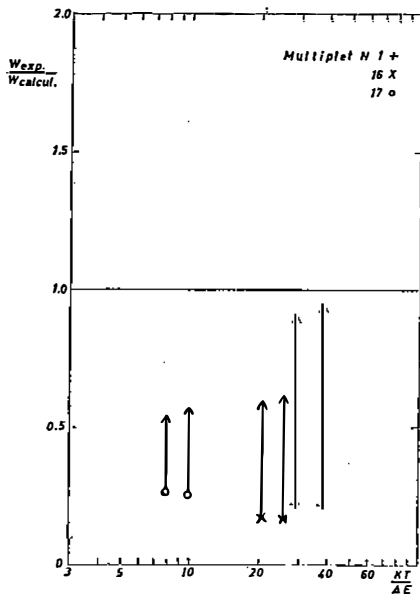


Fig. 1

The vertical arrows indicate changes in the calculated widths, when contributions from various perturbing levels are treated individually rather than lumped together. It is interesting to notice good agreement with the theory for lines of multiplet

$$\text{№ 1 } (W_{meas}/W_{theory} = 0.91)$$

in comparison with multiplet 16 and 17 (average ratios 0.60 and 0.58, respectively). This is related to the calculation of matrix elements. Namely, during the computation of theoretical half-widths it is necessary to evaluate matrix elements for transition considered and if the upper level is nearer to the ionisation potential, the principal effective quantum number becomes large, what results in an overestimation of the half-widths irrespectively of the ratio  $kT/\Delta E$ . Similar disagreement between measured and computed half widths we have found for silicon II line 5868.4 Å, multiplet 8<sup>6</sup>, and argon II line 4609.6 Å multiplet 31, and also lines from multiplet 15<sup>7</sup>.

It seems that further elaboration of the theory in order to eliminate these discrepancies would considerably improve the agreement with experiment.

### References

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