THE ROLE OF PENNING COLLISIONS IN HOLLOW CATHODE HELIUM CADMIUM LASERS

by

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I certify that the substance of this thesis has not already been submitted for any degree and is not being currently submitted for any other degree.

I certify that any help received in preparing this thesis, and all sources used, have been acknowledged in this thesis.

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ABSTRACT

The excitation mechanisms leading to the formation of the $5s^2\ ^2D_{5/2}$ level, the upper level of the 4416 Å transition of Cd^+, have been investigated. Experiments were carried out in both a helium cadmium discharge and corresponding afterglow.

A self absorption technique was used to measure the variation, with current, pressure and oven temperature, of the densities of selected excited helium levels and the cadmium ion ground state. A comparison of the parametric behaviour of the Penning collision rate with the 4416 Å spontaneous emission provided good evidence that Penning ionization was the dominant mechanism leading to laser oscillation at 4416 Å. Gas temperature effects were found to have a significant influence on the interpretation of the experimental results.

Signal averaging techniques were employed to record the pressure, current and oven temperature dependence of the 4416 Å spontaneous decay in the hollow cathode helium cadmium afterglow. The decay was more complex than anticipated but was eventually attributed to the temporal evolution of the helium triplet metastable species in the afterglow. A simplified model of the afterglow was developed and, using the available excited state densities and estimates of the electron and helium ion densities and electron collision rates, the system of coupled differential rate equations was solved and found to be in reasonable agreement with the experimentally observed trends of the 4416 Å decay.

Taken as a whole, the results of the study of the helium cadmium d.c. discharge and afterglow show beyond doubt that Penning ionization is the dominant excitation mechanism of the $5s^2\ ^2D_{5/2}$ level of Cd II.