Infrared Photodetachment Spectroscopy Measurement of the Electron Affinity of Gallium and the Fine Structure of Ga^-

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Synopsis The electron affinity of gallium and the negative ion fine structure splittings of Ga^- have been measured using tunable infrared laser photodetachment threshold spectroscopy. The relative cross sections for neutral atom production were measured with a crossed laser-ion beam apparatus over the photon energy range 0.27 – 0.36 eV. *s*-wave thresholds were observed for opening photodetachment channels from the fine structure levels of the negative ion. A multi-threshold fit with leading term corrections provides accurate energy determinations. The present results resolve the fine structure contributions and are in better agreement with theory than previous experimental results.

Negative ions are of fundamental interest since they are found in a wide variety of physical situations including terrestrial and stellar atmospheres and electrical discharges and plasmas. The extra electron in a negative ion is bound predominantly by electron correlation effects and therefore negative ions provide a rich testing ground for state-of-the-art atomic physics calculations regarding these multi-body interactions.

There is now good agreement between experimental and theoretical determinations of the electron affinity for most atoms, however gallium is a notable exception. A previous experiment [1] used laser photoelectron spectroscopy to obtain 0.43(3) eV for the electron affinity of Ga. A subsequent reanalysis of the data of [1] yielded an electron affinity of 0.41(4) eV [2]. Both of these experimental values differ substantially from a number of theoretical electron affinity determinations, which cluster near 0.30 eV (see for example [3,4]). In the present experiment, we have used tunable laser photodetachment threshold spectroscopy to measure the electron affinity of Ga and the fine structure splittings of its negative ion, Ga^-.

A 12 keV beam of Ga^- ions was perpendicularly intersected with a pulsed tunable OPO beam. Relative total photodetachment cross sections were measured by detecting the fast neutral atoms produced by detachment. The photon energy was scanned from 0.27–0.36 eV.

An *s*-wave threshold was observed due to the opening of the Ga^- ($4p^2\ ^3P_0$) to Ga ($4p\ ^2P_{1/2}$) ground-state to ground-state transition, which defines the electron affinity of Ga. *s*-wave thresholds were also observed for detachment from the J = 1 and J = 2 excited levels of Ga^-, permitting determination of the fine structure splittings. In these experiments, we are able to measure the fine structure specific thresholds with high accuracy, leading to a greatly improved value for the electron affinity. The present value of the electron affinity, determined by tracking contributions from multiple channels, is found to be much lower than previous experimental results [1,2] and is in better agreement with theories [3,4].

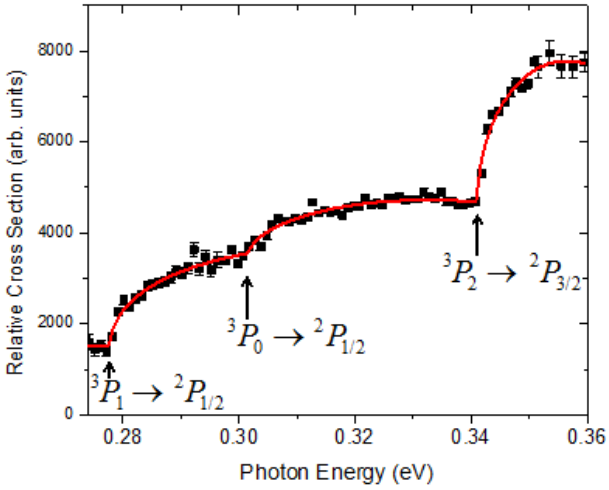

Figure 1. Measured Ga^- photodetachment spectrum showing 3 thresholds and a Wigner Law *s*-wave fit with leading corrections.

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References

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