Cross sections for the photodetachment of B^-

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Cross sections for photodetaching an electron from a B^- ion have been determined at photon energies of 1.871 and 2.077 eV. A crossed laser–ion-beam apparatus was used to determine the cross sections of B^- relative to those of the reference ion Li^-. The ratios were normalized to previously measured cross sections for the reference ion. The present experiment yields values of $\sigma(B^-)=24\pm4$ Mb (1.871 eV) and 21 ± 3 Mb (2.077 eV).

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I. INTRODUCTION

In the present paper we report on the measurement of a cross section for single photon detachment of an electron from the B^- ion. Photon energies of 1.871 and 2.077 eV were used in the experiment. At these energies the process of photodetachment proceeds via the ^2P ks,d final-state channels, i.e., $h\nu+B^-\ (2\,^3P)\rightarrow B(2\,^2P)+e^-(ks,d)$. Figure 1 shows a partial energy-level diagram for the B and B^- systems and bound-free transition studied.

The existence of the B^- ion was first reported by Branscomb and Smith in 1956 [1]. Subsequently, a laser photodetached electron spectroscopy experiment by Feigerle, Cordermann, and Lineberger [2] showed that the ion was stably formed in the $2p^2\,^3P$ state and that it has a binding energy of 0.278 eV. The same experimental crossed-beam technique was later used by Liu *et al.* [3] to investigate the angular distributions of the detached photoelectrons. Asymmetry parameters were measured at four discrete photon energies in the visible. Until the present work, however, to the best of our knowledge, there have been no measurements of cross sections for photodetaching an electron from the B^- ion.

II. EXPERIMENTAL PROCEDURE

A crossed laser–negative-ion-beam apparatus has been used in the present experiment. Energy- and angle-resolved spectroscopic measurements were performed on the photoelectrons that were ejected from the interaction region defined by the perpendicularly intersecting beams. The electrons were collected in the forward direction (in the direction of motion of the ions) and energy analyzed using a spherical-sector electrostatic spectrometer. In order to circumvent the need to determine the details of the interaction region, a ratio method was used. Details of the procedure have been described previously [4]. Briefly, one measures the ratio of yields of photoelectrons detached from the beams of the specie of interest and a reference specie. The two ion beams are constrained to pass through the laser field in an identical manner. The yield ratio is corrected for the fact that certain quantities such as ion beam intensities and velocities, kinematically modified emission solid angles, and photoelectron angular distributions differ for the two species. To eliminate the dependence of the ratio on the relative efficiencies for collection and detection of electrons from the two beams, one chooses the energies of the two ion beams in such a way that the detached electron energies are kinematically shifted to the same energy in the laboratory frame.

Figure 2 shows typical photoelectron spectra for B^-

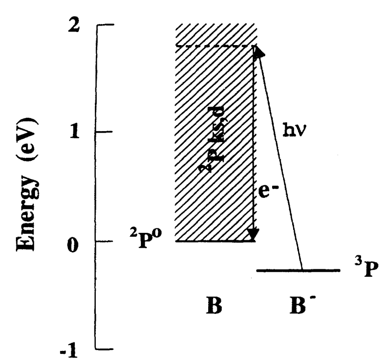

FIG. 1. Partial energy level diagram for the B and B^- systems. The ^2P ks,d photodetachment channels used in the experiment are indicated in the figure.

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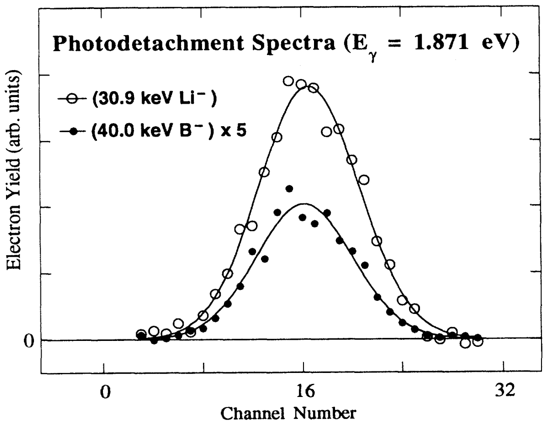

FIG. 2. Spectra of electrons photodetachment from beams of B^- (solid circles) and Li^- (open circles) at a photon energy of 1.871 eV. Different ion beam energies (40.0, 30.9 keV) are chosen to kinematically shift the two groups of electrons to the same energy in the laboratory frame. The two peaks are fitted by Gaussian functions.

and Li^- ions accumulated using beam energies of 40.0 and 30.9 keV, respectively, and a photon energy of 1.871 eV. The two spectral peaks are fitted by the spectrometer response function, chosen to be a Gaussian shape. The ratio of electron yields is determined from the areas under the fitted distributions.

In order to convert the angle-differential measurements into angle-integral ones, one must determine the asymmetry parameters characterizing the angular distributions of electrons ejected in the photodetachment of both the B^- ion and the reference ion. In the case of Li^- photodetachment, the detached electron is represented by a pure *p* wave and the value of $\beta=2.00$ is predicted for all photon energies. This prediction was experimentally confirmed by Dellwo *et al.* [5]. The angular distributions of photoelectrons detached from B^- have been previously investigated by Liu *et al.* [3]. The measured asymmetry parameters were $\beta=0.19$ (1.871 eV) and 0.17 (2.077 eV).

III. RESULTS

The B^- photodetachment cross sections were determined by measuring these cross sections relative to those of a reference ion, which was chosen to be Li^- in this case. The ratios were found to be $\sigma(B^-)/\sigma(Li^-)=0.33\pm0.04$ (1.871 eV) and 0.33 ± 0.03 (2.077 eV). The Li^- photodetachment cross sections have been previously measured by Dellwo *et al.* [5] to be $\sigma(Li^-)=73.5\pm6.0$ Mb (1.871 eV) and 63.5 ± 5.7 Mb (2.077 eV). In the latter experiment the D^- ion was used as a reference and the measured ratios were normalized to theoretical H^- photodetachment cross sections [6]. The B^- photodetachment cross sections, normalized to the Li^- cross sections, are then determined to be $\sigma(B^-)=24\pm4$ Mb (1.871 eV) and 21 ± 3 Mb (2.077 eV). As a check, we also measured, at 2.077 eV, the ratio $\sigma(B^-)/\sigma(Be^-)=0.65\pm0.04$ and normalized it to the value of $\sigma(Be^-)=31\pm3$ Mb recently reported by Pegg *et al.* [7]. This procedure yielded a result of $\sigma(B^-)=20\pm3$ Mb, in good agreement with the value that was referenced to Li^-.

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