Photoionization cross sections and Oscillator Strengths of Excited States of Helium and Lithium

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The measurements of photoionization cross sections of the excited states of helium and lithium using the saturation technique are presented. A DC glow discharge has been used to measure the photoionization cross sections of the $3p\ ^1\mathrm{P}$ and $3p\ ^3\mathrm{P}$ excited states of helium, at the ionization threshold and in the near threshold region (0–2 eV) using a simple experimental setup. A smooth frequency dependence of the cross section has been observed for both the excited states in accordance to the theoretical calculations. A thermionic diode ion detector has been used for the measurements of photoionization cross sections from the $4s\ ^2\mathrm{S}$, $4p\ ^2\mathrm{P}$ and $4d\ ^2\mathrm{D}$ excited states of lithium above the first ionization threshold. The behavior of the photoionization cross sections from $n = 4$ and $l = 0$, 1, 2 excited states have been investigated. A smooth wavelength dependence of photoionization cross section has been observed for the $4p$ and $4d$ excited states, which decrease monotonically with the decrease in the ionizing laser wavelength however the falloff for the $4d$ excited state is purely hydrogenic. The cross section for the $4s$ excited state first increases, attains a maximum value and then decreases monotonically with a decrease in the ionizing wavelength—strictly nonhydrogenic. The measured values of the cross sections are in good agreement with the earlier reported theoretical and experimental values.

In addition, the oscillator strength distribution in discrete and continuous regions of the spectra of helium and lithium has been determined. The saturation technique has been employed to determine the photoionization cross section from the $2s\ ^1\mathrm{S}_0$ excited state of helium and from $3s\ ^2\mathrm{S}_{1/2}$ excited state of lithium at and above the first ionization threshold. The measured value of the photoionization cross section at the ionization threshold has been used to extract the f-values for the $2s\ ^1\mathrm{S}_0 \rightarrow np\ ^1\mathrm{P}_1$ Rydberg series of helium from $n = 10$ to $n = 52$ and for the $3s\ ^2\mathrm{S}_{1/2} \rightarrow np\ ^2\mathrm{P}_{1/2}$ Rydberg series of lithium from $n = 14$ to $n = 56$. In the continuum region the oscillator strength densities have been estimated by measuring the photoionization cross sections from the $2s\ ^1\mathrm{S}_0$ excited state at five ionizing laser wavelengths while from the $3s\ ^2\mathrm{S}_{1/2}$ excited state at four ionizing laser wavelengths above the first ionization threshold. The discrete f-values smoothly merge into the continuous oscillator strength densities and continuity has been found between the discrete and the continuous spectrum across the ionization threshold.