GÖTEBORGS UNIVERSITET

Spectroscopic Studies of the Negative State of Atoms

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Akademisk avhandling för filosofie doktorsexamen i atomfysik, som med tillstånd från Naturvetenskapliga fakulteten kommer att offentligt försvaras fredagen 11:e september 2020 kl. 9.00 från Institutionen för fysik, Kemivägen 9, Göteborg. Åhörare hänvisas att deltaga under det digitala webinariet via länken:
https://gu-se.zoom.us/j/67471165312?pwd=K1QrZWpZaCsrQlUvT0lCK3E4clVsQT09

ISBN: 978-91-7833-976-1, (TRYCK)
ISBN: 978-91-7833-977-8, (PDF)
Available at: http://hdl.handle.net/2077/64417

Abstract

Negative ions are of fundamental interest in atomic physics due to the enhanced importance of the electron correlation. In this thesis new spectroscopic methods have been developed and then applied to study the nature of atomic negative ions. The demand of experimental development in this field is pronounced due to lack of resonant excitations within the atomic negative ion, which makes conventional spectroscopy methods insufficient. Instead, laser photodetachment spectroscopy has been applied in which an ion absorbs a photon resulting in a break up in a neutral atom and an electron. The research has been performed at the Gothenburg University Negative Ion and Laser LAboratory (GUNILLA) and at ISOLDE, CERN.

The work has widened the utilization of spectroscopy techniques to include radioactive elements. For such studies the Gothenburg ANion Detector for Affinity measurements by Laser Photodetachment (GANDALPH) was developed. Of particular interest here is an experimental determination of the electron affinity of astatine of $EA(At) = 2.415\,78(7)$ eV. This work opens for future work on the spectroscopy of transuranium elements and other artificial elements.

Second, a new type of spectrometer for Photoelectron Angular Distribution (PAD) spectroscopy has been developed. In this spectrometer, called PEARLS (Photo-Electron Angular Resolved Linear Spectrometer), the laser and ion beams are collinearly aligned, which considerably increases the interaction volume. The spectrometer was then used to study the energy dependence of the asymmetry parameter β, for photodetachment of negative phosphorous.

Third, a neutral particle detector for collinear spectroscopy is presented. The target material was graphene coated quartz with transparent properties that out-performs the previously used Indium Tin Oxide (ITO). With graphene coating, the accessible energy range is extended to at least 5.3 eV compared to the earlier limit of 3.7 eV.

Finally, an experimental set-up for state selected detection of the residual atom in the photodetachment process has been developed and commissioned. The set-up has been used to measure the EA of cesium to be $EA(Cs) = 0.471\,612(9)$ eV. This work sets the groundwork for investigation of the validity of Wannier's law for three body particle breakups.

Keywords: Atomic Physics, Photodetachment, Negative Ions, Anions, Laser Photodetachment Spectroscopy, Electron Affinity, ISOLDE, CERN, Radioisotopes, Photo Angular Distributions, Graphene, Electron correlation, Neutral Particle Detection, Wannier's Threshold Law.