A 13: Photoionization

Time: Tuesday 10:30–12:15 Location: V55.01

A 13.1 Tue 10:30 V55.01

One- and two-photon single ionization of 1D helium: resolving the role of individual decay channels and resonance states — •Vera Neimanns[1], Pierre Lugan[2], Klaus Zimmermann[1], Felix Joerder[1], and Andreas Buchleitner[1] — [1]Quantum Optics and Statistics, Physikalisches Institut, Universitaet Freiburg, Germany — [2]Laboratory of Theoretical Physics of Nanosystems, Institute of Theoretical Physics, EPF Lausanne, Switzerland

We combine the method of complex rotation and Floquet theory to analyze the multiphoton ionization of helium atoms in strong laser fields. We focus on 1D $Z^{2+}e^-e^-$ helium to highlight the methods that allow us to extract the partial decay rates associated with various decay channels. In the regime of one-photon single ionization, we study the dependence of the partial rates associated with the singly ionized $He^+(N)$ states on the field frequency. We show that the electron-electron interaction provides couplings to higher single-ionization continua. Finally, we examine two-photon single-ionization processes, and analyze the role of the internal electronic structure of the atom, specifically the signature of resonant coupling to intermediate bound states on the decay rates.

A 13.2 Tue 10:45 V55.01

Anderson-like localization effects in electromagnetically driven helium — •Felix Jörder[1], Klaus Zimmermann[1], Vera Neimanns[1], Alberto Rodriguez[1], Pierre Lugan[2], and Andreas Buchleitner[1] — [1]Physikalisches Institut, Albert-Ludwigs-Universität Freiburg i.Br., Deutschland — [2]EPFL, Lausanne, Schweiz

The driven helium atom defines a paradigmatic scenario of a fragmenting quantum system, characterized by high spectral densities and decay channels into multiple continua. A powerful tool to access the spectral structure underlying the field-induced excitation and fragmentation process is provided by complex dilation of the Hamiltonian, which uncovers the pole structure of the resolvent operator and provides insight into the dynamics of the system. The microwave-induced excitation process of helium Rydberg atoms is retarded by Anderson-like (dynamical) localization effects, leading to strongly reduced multiphoton decay rates. We present numerical simulations of this process and study the impact of the interelectronic Coulomb repulsion on the localization behavior.

A 13.3 Tue 11:00 V55.01

Evidence for anisotropic final state interactions in the two-photon ionization of He — •Gregor Hartmann[1], Markus Braune[2], Toralf Lischke[1], Andre Meissner[1], and Uwe Becker[1] — [1]Fritz-Haber-Institut der Max-Planck Gesellschaft, Faradayweg 4-6, 14195, Germany — [2]DESY, Notkestr. 85, 22067 Hamburg, Germany

The photoelectron angular distribution of single photoionization is described by Legendre Polynomial of second order $P_2(\cos\theta)$. Two-photon ionization however, gives rise to a second term being a Legendre Polynomial of fourth order$P_4(\cos\theta)$. This Term for sequential two-photon ionization has a weighting factor given by the alignment of the ionic core left by the first ionization step. If this first step leaves an isotropic core this alignment is zero and the corresponding P_4 term should have no actual effect on the photoelectron angular distribution. In order to prove this theoretical prediction we have performed two-photon ionization experiments at Helium. At higher photon energies the angular distribution of the second step photoelectron followed indeed a P_2-distribution as expected. However, at lower photon energies the photoelectron angular distribution showed small P_4 behavior. We interpret this unexpected result as evidence for anisotropic final state interaction due to a first step final state consisting of a combined system of ionic core and outgoing photoelectron.

A 13.4 Tue 11:15 V55.01

High-resolution time-resolved transient-absorption spectroscopy with continuous VUV spectrum around the first ionisation threshold of helium — •Andreas Kaldun, Christian Ott, Philipp Raith, Kristina Meyer, Martin Laux, Yizhu Zhang, and Thomas Pfeifer — Max-Planck Institut für Kernphysik, Heidelberg

Attosecond time-resolved spectroscopy on helium in the energy range around the first ionization threshold has been performed (see e.g. [1, 2]) however without simultaneous access to a broad energy range at high spectral resolution. In our work, we use a continuous coherent vacuum-ultra-violet (VUV) high-harmonic generation (HHG) spectrum together with our high-resolution VUV spectrometer to resolve the helium absorption lines of the transitions corresponding to the $1s^2 \leftrightarrow 1snp$ states with n ranging from 2 up to 9. By spatially and temporally superimposing the VUV-pulse at variable time delays with a moderately intense few-cycle near-visible (VIS) pulse (precission measured interferometrically to be 10 as) we observe a switching from absorption to emission in the measured spectra. The Data were recorded by scanning the time delay in steps of 170 as and for different VIS laser intensities. Characteristic energy shifts of the resonance lines in the temporal overlap region of VUV and VIS pulse are identified and provide information about the dipole coupling of these excited states with surrounding bound as well as continuum states.

[1] Holler *et al.* PRL **106** , 123601 (2011)
[2] Mauritsson *et al.*PRL **105** , 053001 (2010)

A 13.5 Tue 11:30 V55.01

Precise determination of the ionization potential of astatine by in-source laser spectroscopy — •Sebastian Rothe[1,2], Valentin Fedosseev[1], Nobuaki Imai[1], Bruce Marsh[1], Marica Sjödin[3], Maxim Seliverstov[1], and Klaus Wendt[2] — [1]CERN, Geneva, Switzerland — [2]Institut für Physik, Uni Mainz, Germany — [3]GANIL, Caen, France

On-line in-source laser resonance ionization spectroscopy of the exclusively radioactive element astatine was performed at CERN/ISOLDE, representing the first ever laser spectroscopy on that heaviest halogen element. An efficient ionization scheme was developed and the first precise determination of the ionization potential of astatine atoms was carried out. Due to the absence of long lived isotopes of astatine, on-line production at the ISOLDE isotope separator facility at CERN was required. During a first measurement campaign, the ionization potential was located within a range of 100 cm^{-1} by photoionization threshold spectroscopy. This work was a prerequisite for the precision spectroscopy of high lying Rydberg states which was performed by scanning one of the RILIS lasers across the corresponding wavelength range. The observed Rydberg levels converge towards the ionization potential which was determined as 75151(1) cm^{-1}. The efficient ionization scheme for astatine will also enable further precision in-source spectroscopy of isotope shifts and hyperfine structure as well as the study of beta delayed fission of the isotopes $^{194-199}$At.

A 13.6 Tue 11:45 V55.01

Phase Dependence of the β-Oscillations in N_2 and O_2 — •Markus Ilchen[1], Markus Braune[1,2], Sascha Deinert[1], Leif Glaser[1], André Meissner[2], Frank Scholz[1], Lokesh Tribedi[2,3], Peter Walter[1], Jens Viefhaus[1], and Uwe Becker[2] — [1]DESY, Hamburg, Germany — [2]Fritz-Haber-Institut, Berlin, Germany — [3]Tara Institute of Fundamental Research, Mumbai, India

Oscillations in the partial photoionization cross sections of homonuclear diatomic molecules have been described by Cohen and Fano more than 40 years ago as an interference phenomenon analogous to a double slit experiment. These cross section oscillations have been verified by several experiments in the meantime. In addition to the cross section however, also the angular distribution asymmetry parameter β and most likely all spin parameters are showing oscillations. The physical reason of these oscillations has not necessarily to be only the partial cross section and such effects could also be caused by phase shifts of the outgoing photoelectron partial waves. Photoionization of homonuclear diatomic molecules such as H_2, N_2 and O_2 should show non-vanishing oscillating spin polarization in this respect. A persisting oscillation after multiplication of the oscillations of β and $\sigma_{partial}$ indicates a dependence on the phase shift of the photoelectron partial waves. In the light of a double slit experiment this is unexpected and has to be discussed by theory more deeply.

A 13.7 Tue 12:00 V55.01

Spektroskopische Untersuchungen an Uranisotopen mittels hochauflösender Resonanzionisationsspektroskopie — •Amin Hakimi[1], Thomas Fischbach[1], Sebastian Raeder[3], Norbert Trautmann[2] und Klaus Wendt[1] — [1]Institut für Physik, Johannes-Gutenberg-Universität Mainz — [2]Institut für Kernchemie, Johannes-

Gutenberg-Universität Mainz — [3]TRIUMF, Vancouver, Canada

Im Rahmen der nuklearen Forensik besteht die Notwendigkeit der präzisen Bestimmung des Isotopenverhältnis $^{236}U/^{238}U$, welches Hinweise auf die Herkunft einer uranhaltigen Probe liefert. Da das Isotopenverhältnis zumindest bis hinab zu 10^{-10} gemessen werden muss, um die Signatur einer anthropogenen Kontamination vom natürlichen Untergrund unterscheiden zu können, muss eine Messmethode höchster Isotopenselektivität eingesetzt werden. Hier bietet sich neben der aufwändigen AMS die hochauflösende Resonanzionisations-Massenspektrometrie (HR-RIMS) als kompaktes Verfahren an. Für eine nachhaltige Verfügbarkeit dieser Methode sollen zur optischen Besetzung erster Schritte der dreistufigen optischen Anregungs- und Ionisationsleiter blaue Laserdioden um 405 nm (BluRay) eingesetzt werden. Ausgehend von diesem Energiebereich sind nur wenige hochliegende gebundene Zwischenzustände und autoionisierende Resonanzen charakterisiert. Der aktuelle Entwicklungsstand der HR-RIMS an Uran wird präsentiert und ihre analytische Anwendung erläutert. Als Vorarbeit für eine nachhaltige Methodensicherung werden die notwendigen spektroskopischen Untersuchungen vorgestellt.