A 19: Precision spectroscopy of atoms and ions II (joint session A/Q)

Time: Wednesday 14:00–15:15 Location: A-H2

A 19.1 Wed 14:00 A-H2

Ionization potential, atomic and nuclear structure of $^{244-248}$Cm by laser spectroscopy — •Nina Kneip[1], Felix Weber[1], Magdalena A. Kaja[1], Christoph E. Düllmann[1,2,3], Christian M. Marquardt[4], Christoph Mokry[1,2], Petra J. Panak[4], Sebastian Raeder[2,3], Jörg Runke[1,3], Dominik Studer[1], Petra Thörle-Pospiech[1], Norbert Trautmann[1], and Klaus Wendt[1] — [1]Johannes Gutenberg University, 55099 Mainz — [2]Helmholtz Institute, 55099, Mainz — [3]GSI Helmholtzzentrum für Schwerionenforschung GmbH, 64291 Darmstadt — [4]Karlsruhe Institute of Technology, 76131 Karlsruhe

Curium (Z=96) is located in the middle of the actinide series and has a half-filled atomic f shell with a ground state configuration $5f^7 6d 7s^2$ $^9D_2^o$. One ton of spent nuclear fuel, contains up to 20 g of ^{248}Cm, generated by multiple neutron capture of ^{238}U. This environmental aspect in combination with its long half-life of 328 Ma motivates fundamental laser spectroscopic studies on the actinide. Resonance ionization spectroscopy was applied to study the atomic and nuclear structure of the isotopes, $^{244-248}$Cm was spectroscopically investigated. Three different ground state transitions were used as first excitation steps. Scanning the laser around the expected value of the ionization potential (IP), numerous Rydberg levels and auto-ionizing levels were located. The IP was re-determined using field ionization and Rydberg convergence techniques for comparison. The hyperfine structure of ^{245}Cm and ^{247}Cm and the isotopic shift in the isotope chain $^{244-248}$Cm were measured for the first time by laser spectroscopy.

A 19.2 Wed 14:15 A-H2

A new type of spectroscopy: Direct observation of hyperfine transitions with energy differences of 10 neV and below — •Chrysovalantis Kannis — Institut für Kernphysik, Forschungszentrum Jülich, Jülich, Germany — III. Physikalisches Institut B, RWTH Aachen University, Aachen, Germany

Spectroscopy is a tool commonly used for the study of the energy levels of a sample. In most applications the sample is trapped, however this is not always feasible. An alternative type of spectroscopy includes a static external field and a moving sample. In particular, we use two opposed solenoidal coils which provide a static magnetic field with field direction reversal along the polarization axis. This produces a sinusoidal longitudinal (along the quantization axis) magnetic field component with a zero crossing between the coils. In addition to the longitudinal component, a radial component is also induced which is proportional to the gradient of the first and the distance from the center of the quantization axis.

For an atomic beam of metastable hydrogen with a kinetic energy of about 1 keV and a magnetic field configuration with a wavelength $\lambda \sim 10$ cm, the induced transitions correspond to an RF frequency $f = v/\lambda$ in the MHz range. Equivalently, the energy difference between various levels is of the order of 10^{-8} eV and below. These can be found between hyperfine substates of hydrogen atoms at low magnetic fields in the Breit-Rabi diagram. Here we present first measurements, their interpretation, and possible applications.

A 19.3 Wed 14:30 A-H2

Laser spectroscopy of muonic ions and other simple atoms — •Randolf Pohl — Johannes Gutenberg Universität Mainz

Laser spectroscopy of simple atoms is sensitive to properties of the atomic nucleus, such as its charge and magnetization distribution. This allows determining the nuclear parameters from atomic spectroscopy, but also limits the attainable precision for the determination of fundamental constants or the test of QED and the Standard Model. In light muonic atoms and ions, one negative muon replaces all atomic electrons, resulting in a calculable hydrogen-like system. Due to the muon's large mass (200 times the electron mass), the muon orbits the nucleus on a 200 times smaller Bohr radius, increasing the sensitivity of muonic atoms to nuclear properties by 200^3 = 10 million. Our laser spectroscopy of muonic hydrogen through helium has resulted in a 10fold increase in the precision of the charge radius of the proton, deuteron, and the stable helium nuclei. Next we're measuring the hyperfine splitting in muonic hydrogen to obtain information about the magnetization of the proton. In Mainz, we're setting up an experiment to determine the triton charge radius by laser spectroscopy of atomic tritium.

A 19.4 Wed 14:45 A-H2

Resonance ionization mass spectroscopy on Americium — •Matou Stemmler[1], Felix Weber[1], Christoph Düllmann[2,3,4], Dominik Studer[1], Anjali Ajayakumar[5], and Klaus Wendt[1] — [1]Institut of Physics, Johannes Gutenberg-Universität Mainz, Germany — [2]Department of Chemistry - TRIGA site, Johannes Gutenberg-Universität, Germany — [3]Helmholtz Institut Mainz, Germany — [4]GSI Helmholtzzentrum für Schwerionenforschung GmbH Darmstadt, Germany — [5]GANIL, France

Americium (Am, Z=95) is a transuranic member of the actinide series which can be produced artificially by neutron bombardment in nuclear reactors or explosions. All its isotopes are radioactive and the two most long-lived isotopes are ^{241}Am and ^{243}Am with half-lifes of $t_{1/2}$=432.2 y and $t_{1/2}$=7370 y respectively. Here we report on high resolution laser spectroscopy on Am. About $3 \cdot 10^{13}$ atoms of both isotopes ^{241}Am and ^{243}Am were prepared on zirconium foil and loaded into a resistively heated tantalum oven. A wide range tuneable, frequency doubled, continuous wave Titan:Sapphire laser was used for spectroscopy by injection locking of a high power pulsed Ti:Sa ring laser setup. Hyperfine structures of the two isotopes were investigated in two different ground state transitions, which served as first excitation steps for resonant ionisation via suitable autoionizing states. In addition, the isotope shift was determined in one of these transitions. Data analysis regarding the atomic structure of Am as well as hyperfine parameters extracted will be discussed.

A 19.5 Wed 15:00 A-H2

Laser spectroscopy of neptunium - excitation schemes, atomic structure and the ionization potential — •Magdalena Kaja, Dominik Studer, Felix Weber, Felix Berg, Nina Kneip, Tobias Reich, and Klaus Wendt — Johannes Gutenberg University, 55099 Mainz

Neptunium is a radioactive actinide and the first transuranic element. In particular, ^{237}Np is generated quantitatively within the nuclear fuel cycle with amounts on average ∼10 kg in each conventional pressurized water reactor each year. Due to its long half-live of $2.1 \cdot 10^6$ years and high radiotoxicity, it represents a major hazard in the final disposal of nuclear waste. Under environmental conditions, Np can be present in oxidation states +III to +VI and can form soluble species. In this context trace analysis of environmental samples is of high relevance. The development of efficient and selective laser ionization schemes plays an important role for Np spectroscopy and trace analysis.

The spectrum of Np has been studied at the Mainz Atomic Beam Unit, using widely tunable frequency-doubled Ti:Sapphire lasers. The ionization scheme development, spectra above and below the ionization potential (IP), as well as the electric field ionization technique, which allows the determination of the IP, are presented in this contribution. Narrow-band spectroscopy is planned to determine hyperfine structures and isotope shift. So far, only ^{237}Np has been studied by laser spectroscopy and only in broad-band mode. Therefore, high-resolution spectroscopy is planned on ^{237}Np and possibly on the short-lived isotope ^{239}Np.