Bound electron g-Factor measurements at the HITRAP facility

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We are currently commissioning ARTEMIS, a Penning trap experiment designed to measure the magnetic moments (g-factors) of highly charged ions. In the theory of bound state quantum electrodynamics (BS-QED) g-factors can be calculated to high accuracies. With the aimed high precision measurement we can test QED at a ppb level and beyond. The method of use is the so-called microwave laser double-resonance spectroscopy, utilizing the fact that for some medium charged ions the fine-structure and for some heavy highly-charged ions the hyperfine-structure splitting is in the optical regime. These ions, such as $^{207}Pb^{81+}$ and $^{209}Bi^{82+}$, for example, will be available within the framework of the HITRAP facility ARTEMIS is connected to. For first offline tests, $^{40}Ar^{13+}$ has been chosen. It has a spinless nucleus, so that the g-factor of the 2p electron can be measured. Due to the high magnetic field of 7 T also first laboratory measurements of higher-order Zeeman effects can be studied.

Figure 1: Photography of the ARTEMIS trap chamber with the electronics, for example ion motion detection circuits, laser inlet and filterboards.

Here we present our progress in the in-trap production of boron-like argon. First, argon gas is injected in the cryogenic adsorption valve that can be heated above the adsorption temperature of argon for "opening". The creation of different charge states takes place by electron-impact ionization like the charge-breeding processes used in electron beam ion sources (EBIS). By setting different voltages to the field emission tip, the electron energy is adjusted such that different charge states can be produced. The ions are trapped in a three-fold nested Penning trap ensemble within a ten-electrode mechanically compensated creation trap tower. They are concentrated into one trap. With our superconducting NbTi resonator, the axial motion at 630 kHz is detected non-destructively. By ramping the potential of the trap between 1 V and 250 V, the axial frequencies of the different ion species inside the trap are brought into resonance with the resonator, and thus a spectrum with different M/Q (mass-to-charge ratio) is recorded. With our ultra-high vacuum, storage times (even for the higher charge states like Ar^{16+}) of many hours up to days have been achieved so far.

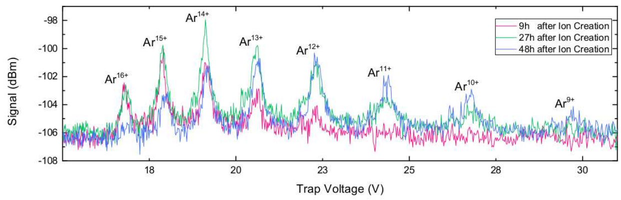

Figure 2: Time evolution and charge exchange of the different argon charge states.Trap voltage is related to the mass-to-charge ratio of the trapped ions.

In a next step, all ion species but Ar^{13+} will be removed from the trap, and the remaining ions will be transported to the precision trap where cyclotron detection and measurements of the electron magnetic moment will take place. The 441 nm laser system has been set up at GSI and is currently being equipped with a secondary tellurium spectroscopy for higher laser stability.

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