HITRAP: New Opportunities for Studying Highly Charged Ions in Extreme Electromagnetic Fields

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The Highly charged Ion TRAP (HITRAP) facility at GSI (Fig. 1) is approaching completion. Commissioning is expected for autumn 2008. HITRAP uses the GSI relativistic ion beams and the Fragment Separator FRS, if required, for production of radionuclides, the Experimental Storage Ring ESR for electron cooling and deceleration to 4 MeV/u, a combination of an interdigital H-type (IH) structure with a radiofrequency quadrupole structure for further deceleration to 6 keV/u and a Penning trap for accumulation and cooling. Finally, ion beams with low emittance are delivered to a large variety of atomic physics experiments. Transferred to and stored in an ion trap kept at 4 K, a trapped, point-like and backing-free sample is realized. It consists of stable or radioactive ions nearly at rest in space and in a specific charge state, i.e. as an ion cloud of bare nuclei without any electron or of highly charged ions with one or very few electrons. Such a situation allows for highest accuracy from the experimental as well as from the theoretical point of view. For the most ambitious case, U^{92+}, we expect to load the cooler trap every 10 seconds with 10^5 ions.

The experimental program of HITRAP will focus on testing quantum electrodynamics (QED) of bound electrons in the strongest electromagnetic fields producible in the laboratory for extended periods of time. This can be achieved by measuring the g-factor of the bound electron, the binding energies of a single or of few electrons including the Lamb shift, or the hyperfine structure (HFS) of a stable isotope of an element in different high charge states with utmost accuracy. The results for stable isotopes are then compared with state-of-the-art QED calculations. If the QED effects are under control so that they are calculable with sufficient accuracy or if they can be almost eliminated by measuring the same nuclear quantity in different charge states, the results can be used also to address questions in metrology, in nuclear physics and particle physics.

Figure 1: The HITRAP facility under construction at GSI.