GEC10-2010-000038

Abstract for an Invited Paper
for the GEC10 Meeting of
the American Physical Society

Electron-ion collisions: precision spectroscopy and plasma rate coefficients[1]

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Charge-changing interactions of electrons with target ions A^{q+} are studied. Cross sections and rate coefficients are measured and the resonant excitation of the ions is employed in a new type of precision spectroscopy. Using charged particles as targets implies a number of advantages and special aspects that can be exploited in experiments. Beams of charged particles can easily be analyzed and selected with respect to the mass, the charge state and the energy of the particles. Hence, a beam of charged particles can provide a very well characterized pure target for collision and spectroscopy experiments. The determination of target density distributions is difficult but the use of energetic charged particles also offers the potential of very accurate measurements. Plasma environments, man-made or of natural origin, often contain ions in high charge states. Understanding plasma properties requires detailed and accurate knowledge of energy-dependent electron-ion cross sections specified by the charge state of the ions. Moreover, variation of the charge states of the target ions provides access to measurements along iso-electronic sequences in which the number of electrons in the system is kept constant, while the atomic number Z and the charge state q are varied. Along an iso-electronic sequence the relative importance of electron-nucleus and electron-electron interactions gradually changes, thus providing an opportunity to experimentally disentangle their influence on the structure and dynamics of the atomic system studied. Collisional spectroscopy exploiting resonance phenomena in electron-ion interactions provides an efficient new tool to test the most advanced theoretical calculations of atomic energy levels and their decay properties, to investigate the validity of quantum electrodynamics in strong fields, to understand atomic and molecular physics at the borderline to nuclear physics and to gain insights into the influence of collective effects as well as the response of a single atom on the properties of molecules or atomic clusters under the gradual increase of the number of atoms in the system. Electrons are especially fine probes for studying properties of atomic systems. High resolution measurements are possible due to the availability of very highly developed instrumentation, the possibility to exploit kinematic advantages and the selectivity of electron-ion interactions.

[1]Support by the German Ministry of Education and Research BMBF is gratefullly acknowledged.