Atomic Collisions and Spectroscopy at the Heavy-Ion Storage Ring TSR

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The storage ring TSR is used to cool and accumulate a wide range of heavy-ion beams produced at the Max-Planck Institute for Nuclear Physics in Heidelberg, Germany. With ionization stages reaching up to 50 (bare nuclei up to Cl^{17+}) and beam energies of typically 5–8 MeV/u, storage lifetimes amount to minutes up to hours; repeated cycles of injection and electron cooling (reducing the ion beam diameter from centimeters to millimeters in about 2 sec) make it possible to accumulate beam currents up to 1 mA in the ring.
With the circulating beam, in particular the interaction of multicharged atomic ions with electrons of variable, well defined energies (10 meV to 3 keV) is studied, detecting recombination and electron impact ionization. High-resolution spectra of the dielectronic recombination cross section have been obtained, which provide a sensitive test for atomic-stucture calculations describing the large number of doubly excited states contributing to the recombination rate. For lithiumlike ions (Si^{11+}, Cl^{14+}) all possible outer- and inner-shell excitations were investigated[1]. Low-energy dielectronic recombination measurements are presently being extended[2] also to more complex open-L-shell ions (Fe^{17+}–Fe^{23+}). Very recently the enhancement of dielectronic recombination by ambient electric fields was studied with Cl^{14+}; at well-controlled fields of order 100 V/cm the enhancement of the cross section by up to a factor of 3 in certain energy regions could be followed in detail[3].
In addition to the information on doubly excited levels from dielectronic recombination experiments, spectroscopic results on multicharged ions were also obtained by laser-stimulated recombination[4], allowing highly excited levels in multicharged ions to be reached by laser transitions from continuum states populated by surrounding free electrons. Moreover, for a number of metastable levels in multicharged ions the natural lifetimes in the millisecond to second range could be determined with high accuracies of about 0.2%, using dielectronic resonances to identify metastable ions and also direct optical observation of vacuum-ultraviolet emission[5].

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