A Zero-Degree Electron Spectrometer for (e,2e) Spectroscopy at the ESR

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The jet target of the ESR provides unprecedented conditions to study atomic collision dynamics in the realm of relativistic ion beams. A complete rebuild of the target environment has broadened the range of possible experiments considerably. Besides x-ray spectroscopy, now recoil-ion momentum and electron spectroscopy experiments can be conducted.

Presently we are implementing a magnetic electron spectrometer at the ESR storage ring dedicated to 0^0-electron spectroscopy in collisions of stored ions with gaseous and cluster targets at the gasjet target region: we will focus on high resolution electron spectroscopy of Rydberg states of the projectile and on electrons in the projectile continuum, emphasizing electron impact ionization (e,2e) of the projectile. The spectrometer expands the possibilities of the new longitudinal reaction microscope (RM)[1] for kinematically complete experiments with relativistic ions in the ESR.

In recent experiments the fundamental process of Coulomb ionization of atoms and ions has been investigated in kinematical complete experiments using the reaction microscope[1,2]. The break-up of atoms, i.e. Single and Multiple Ionization (SI, MI) for weak and strong perturbing fields and perturbation times down to 10^{-18} sec have been studied[2] with respect to the dependence of the emission characteristics of electrons on the momentum transfer **k** from the dipolar (small **k**) to the binary regime (large **k**).

Applying the reaction microscope we have begun, first at low collision energies, to investigate for the first time kinematically complete electron impact ionization (e,2e) of ions[2] which is inaccessible to standard crossed beam techniques due to insufficient luminosity.

(e,2e) collision channels in ion-atom collisions are characterized by simultaneous correlated emission of a fast electron with $v_e \cong v_{Projectile}$ in a narrow cone around the projectile direction and a slow electron, mostly in the forward hemisphere. In the reaction microscope all collision products are detected with near 4π efficiency; for collision energies well below 4AMeV mapping both, the fast and the slow electron onto one multihit capable detector still results in an acceptable momentum resolution. The collision plane of the ionizing collisions is then event-wise reconstructed.

This technique gains orders of magnitude in luminosity over standard crossed beam techniques which are restricted to one collision plane predefined by detector geometry with correspondingly low efficiency. This way one opens up the avenue to electron impact ionization of few-electron highly charged ions over the entire Z range.

However, for collision energies above ≈ 4AMeV, it is not acceptable to map the fast and the slow electron onto one multihit capable detector. For this reason an independent magnetic spectrometer is necessary at ESR energies which guides electrons emitted into a narrow cone around the beam direction onto a position sensitive detector and which allows to reconstruct the initial momentum of the fast electron. The design criteria for construction of the instrument are a) separate electrons from the flood of secondary products with minimum interference with the ESR beam, b) analyze electrons emitted in a direction near 0^0 close to the beam over a wide range of momenta including $v_e \cong v_{Projectile}$ up to specific projectile energies of 560AMeV; in non-position sensitive mode a momentum resolution $\Delta p/p = 10^{-3}$ is desired, c) in position sensitive mode, reconstruct the emission direction of the electron in the target zone after transport from the jet-target in the ESR to the detector.

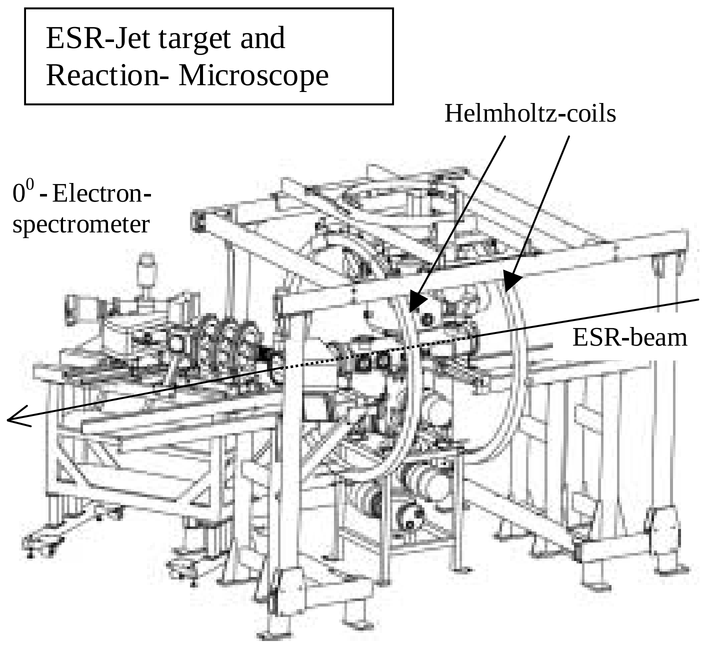

Fig.1: ESR with supersonic jet target environment and downstream 0^0 magnetic electron spectrometer

The design chosen using beam trajectory calculations with the Mirko code is of D-T-D type and covers a solid angle of $4\ 10^{-4}$ sr. A 60^0 magnetic dipol of bending radius 200mm, with an aperture of vertically 100mm and horizontally 250mm as required by the ESR, 940mm from the target zone and just downstream of the target chamber is followed by a magnetic quadrupole triplett of 80mm aperture and a second dipole, identical to the first one. This is followed by a pair of horizontal slits and 2D position sensitive electron detector. As an option an open hyperpure Ge detector for independent analysis of the energy of electrons and identification of other particles potentially transmitted through the spectrometer will be installed during commisioning of the spectrometer as the low energy spectrum of secondary particles produced in the ESR target zone is currently not known.

[1] J. Ullrich et al., J.Phys.B30(1997)2917
[2] R.Moshammer et al, this Annual Report