Polarization Studies for Radiative Electron Capture into High-Z Ions

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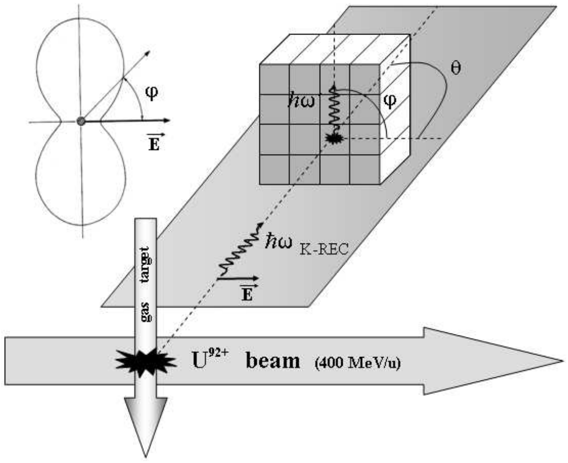

Figure 1: Linear photon polarization measurement by exploiding the Compton effect within an segmented Ge(i) detector.

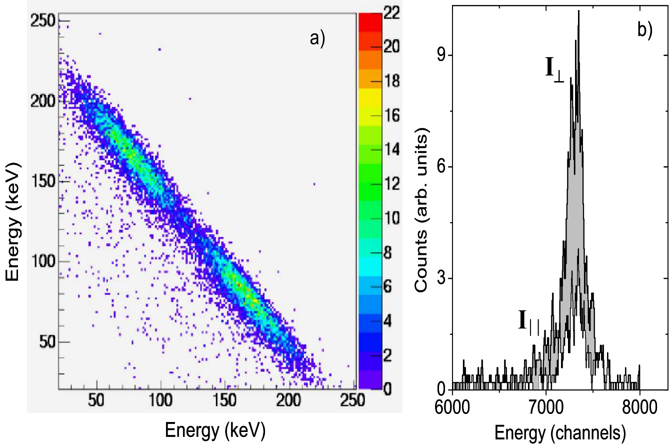

Figure 2: a): Scatter plot of coincident Compton events; b) the coincident sum energy spectrum for scattering parallel ($I_{\|}$, white area) and perpendicular ($I_{\perp}$, shaded area) to the scattering plane.

Very recently, the linear polarization of photons produced by radiative electron capture (REC, the time reversed photoionization in ion-atom collisions) has attracted particular interest [1,2]. However, up to now, no such data are available for the high-Z regime. To the best of our knowledge, this holds also true for photoionization studies of heavy elements. This topic can be addressed experimentally with high efficiency by a new generation of segmented germanium detectors allowing for energy as well as position resolution. Here polarization measurements can be performed by exploiting the dependence of the differential Compton scattering cross-section on the linear polarization of the initial photon (see e.g. [3]).

For bare uranium ions (400 MeV/u) a very first polarization study for REC into the K-shell has recently been performed at the jet-target of the storage ring ESR. For this purpose a 4x4 planar germanium pixel detector with a pixel size of 7x7 mm has been used [4], mounted at an observation angle of 90° (for the geometry of the experiment compare Fig. 1). In the experiment the photon polarization can be derived from a coincident registration of events occurring simultaneously in two pixels. Here, one pixel registers the Compton recoil electron (ΔE) and the other the outgoing scattered photon ($\hbar\omega'$). In Fig. 2 a scatter plot of such coincident photon events is displayed. The intense diagonal reflects a constant sum energy equal to the K-REC transition, i.e. $E_{K-REC} = \Delta E + \hbar\omega'$. It is important to mention that for our initial energies ($E_{K-REC} \approx 250$ keV) the condition $\Delta E < \hbar\omega'$ is always fulfilled which allows us to identify the segment where scattering took place. The latter also explains the two maxima present in the 2D scatter plot. In Fig. 2 we compare the coincident sum energy spectrum for scattering parallel ($I_{\|}$) and perpendicular ($I_{\perp}$) to the scattering plane (defined by the ion beam and K-REC photon). From this figure we can already state that the K-REC radiation is strongly polarized within the scattering plane (for unpolarized target electrons and projectiles, polarization can take place only within or perpendicular to the scattering plane [1,2]). An accurate value for the linear degree of polarization can finally be obtained by analyzing all the different combinations of pixel pairs. Presently, the data evaluation is in progress.

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