Strong correlation between the electron spin orientation and bremsstrahlung linear polarization observed in the relativistic regime

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Atomic field bremsstrahlung is one of the dominant radiation processes in relativistic collisions of electrons with atoms. It arises due to the decelerated motion of the electron scattered in the Coulomb field of the atomic nucleus. The radiation, emitted in the form of x-rays and gamma-rays, is strongly polarized. Polarization reveals details of the dynamics of the scattering electron. Experiments at the electron energy of 100 keV have shown that the x-ray polarization plane generally does not coincide with the reaction plane when the incoming electrons are spin-polarized. The latter is defined by the incoming electron and the emitted x-ray propagation directions. When the electron spin is confined to the reaction plane, the plane of x-ray polarization tilts with respect to the reaction plane [1,2,3]. These observations point to the effect of the spin-orbit interaction in electron scattering and bremsstrahlung.

The spin-effect, observed in previous experiments, was small, causing a few degrees tilt of the polarization plane. On the other hand, due to the relativistic nature of the spin-orbit interaction, it is expected that this effect should be markedly increased at higher energies [4,5]. We have studied bremsstrahlung produced by polarized electrons with 2 MeV kinetic energy colliding with a thin gold target. Gamma-ray linear polarization was measured with the Compton polarimetry technique applied to a segmented germanium detector, see Fig. 1. The Compton-recoiled electron and the scattered gamma-ray were detected in time-coincidence in separate detector pixels. This allowed sampling of the complete azimuthal angular distribution of the scattered gamma-rays and determination of the polarization angle. Moreover, in the same experiment, we have developed the technique of ambient radiation background suppression based on Compton imaging.

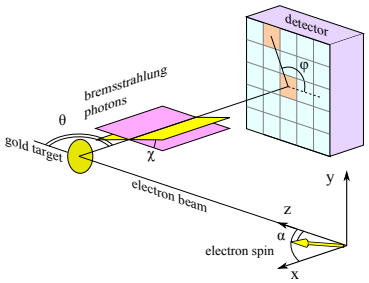

Figure 1: *Scheme of the experiment.*

The experiment revealed a dramatically increased polarization correlation – for the electron beams polarised along and opposite to their propagation directions, the measured tilts of the gamma-ray polarization plane were 49 ± 6 and 125 ± 6 deg, respectively. These results are in agreement with the full-order relativistic calculations. They demonstrate a prominent role of the electron spin interactions in the process of bremsstrahlung as well as Coulomb scattering.

References

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