Experimental studies on elastic X-ray scattering*

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Photon scattering in the presence of strong electromagnetic fields has been studied in an experiment where hard X-rays (175 keV) were elastically scattered by a high-Z (gold) target. Previous studies already covered a broad range of photon energies and target materials [1, 2]. While in most of those experiments the differential scattering cross section was studied, we performed a combined measurement of the angular distribution and the angle-dependent linear polarization of elastically scattered hard X-rays. As in this energy regime the scattering cross section is relatively small, in particular at backward angles, a high-intensity photon source for monoenergetic hard X-rays was required. Moreover, for our study we wanted to use polarized inicdent X-rays. These requirements made the use of a novel 3rd generation synchrotron radiation source mandatory. On the other hand, we needed an efficient polarization-sensitive detector which could be fulfilled with a large-volume, segmented solid state detector that can act as a Compton polarimeter. The incident 175-keV photon beam was provided by the High Energy Material Science Beamline P07 [3] at the synchrotron radiation source PETRA III at DESY, Hamburg. It was scattered by a thin solid gold target and the scattered radiation was detected by a 2D Si(Li) strip polarimeter [4] and a standard high-purity germanium detector. This setup allowed the parallel measurement of the differential cross section and the polarization. In this report, we present preliminary results for the differential cross section, the analysis of the polarization will follow later. Figure 1 (a) shows the energy spectrum of the germanium detector mounted at a scattering angle $\theta = 30°$. The main features are the Rayleigh peak (elastically scattered photons), the Compton peak (inelastically scattered photons) and the Au Kα and Kβ lines (fluorescence from the target). The differential cross section is obtained by determining the intensity of the Rayleigh peak and normalizing it to (i) the Au-Kα_1 cross section and (ii) the Compton cross section. This procedure allows to cancel effects from the experimental geometry and fluctuations in the incident beam intensity. The main task of the data analysis was the area determination of the Kα_1-, the Compton- and the Rayleigh peak. For the narrow Kα_1- and Rayleigh lines, the sum of an analytical peak shape and a linear background was fitted to the data. For the broad Compton peak, a non-analytical fit curve based on the theoretical Compton profile of gold was created. A Monte Carlo simulation corrected the distribution for photons that were scattered from parts of the target chamber. The spectrum from the simulation - corrected for detector efficiency and resolution was then the fit function. Preliminary results are shown in figure 1 (b).

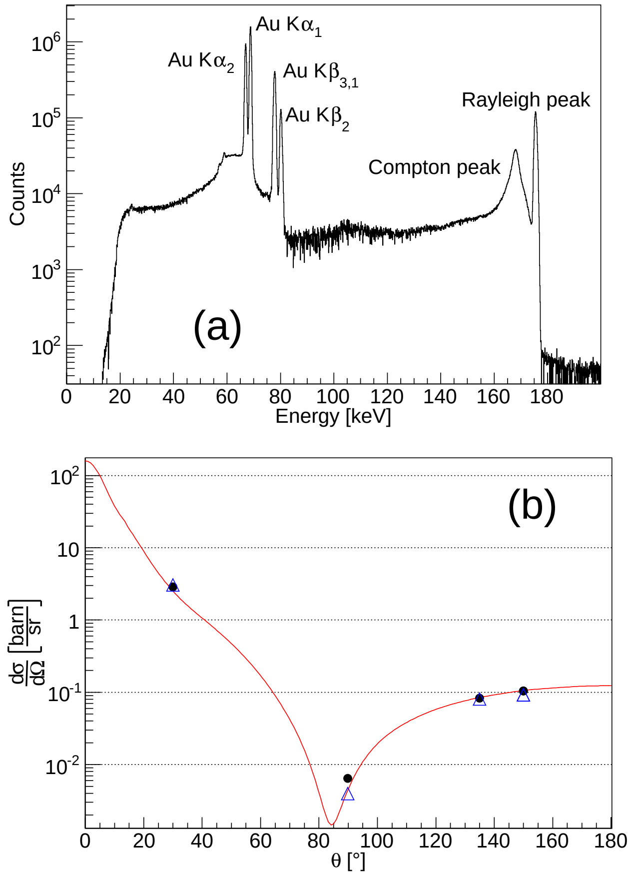

Figure 1: Preliminary results: (a) Energy spectrum of the germanium detector at $\theta = 30°$; (b) Differential cross section: Kα_1 normalization (solid circles), Compton normalization (open triangles), preliminary theory [5] (solid line). Statistical errors are smaller than the point size, systematic errors are not yet included.

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