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Report:

We have performed measurements of the fluorescence yield of Germanium single crystal in $\vec{q} \parallel [110]$ direction using the spectrometer for high resolution resonant inelastic scattering in inverse geometry scanning the primary energy over an energy range from 11.1 to 12.1 keV in the Compton regime at 160° scattering angle to get information about the interference term between Compton and resonant scattering /I/ and at 90° to get the pure fluorescence yield without contributions from Compton scattering and interference. The interference term should give useful information about the phase of the electron momentum space wave function.
The spectra at 90° and 160° scattering angle show an intensity difference (dotted line), caused by the correlation of the polarization dependence of the absorption and emission process, which leads to a variation of the fluorescence yield with the scattering angle /2/. This polarization induced difference, obtained by fitting the two spectra within an energy range where no influence of the interference term is expected, is plotted in Figure 1, compared to the pure difference of the fluorescence spectra (dashed-dotted). Both differences are multiplied by a factor of 10. The polarization induced difference concerning the fluorescence yield is reduced to higher primary energies, which could possibly be due to a reduction of the correlation between the absorption and reemission process with rising energies.
The pure difference of the spectra at 90° and 160° corrected by the polarization induced contribution should deliver the Compton profile superimposed by the interference term (short dashed). The difference has no significant Compton profile symmetry with respect to $p_z = 0$, which is marked with the arrow in Figure 1, and the modulation of the Compton profile by the interference term is less than 0.5 % of intensity of the fluorescence spectra. This unexpected minor effect could be caused on the one hand by the small+ range of final states, which contributes to both processes. If one considers the energy conservation *and* the k selectivity in the process only a small part of occupied and unoccupied states is selected for contributing to the interference term. On the other hand the phase coherence of the two processes could be markedly reduced at high photon energies.
In addition we have measured the $K\beta_2$ fluorescence of Germanium using the equipment for high resolution resonant inelastic scattering at 90° and 160°, to get information about the satellite peaks at the high energy side of the fluorescence (Figure 2).

The first satellite appears independently from the primary energy in the range from 11.2 to 12.6 keV and is shifted about 12 eV from fluorescence maximum. On the other hand the second satellite shows an energy threshold between 11.2 and 11.4 keV primary energy.

To examine this threshold in an exact way, we have performed a scan in inverse geometry, setting the analyzer on top of the second satellite, 24 eV far from the fluorescence and scanning the primary energy. The satellite shows a definite threshold at 127 eV energy loss, which corresponds to an energy difference of 151 eV to the $K\beta_2$ fluorescence (Figure 3). This satellite can be indicated as a $K\beta_2$ satellite traced back to double ionization of K and $M_{II,III}$ [3]. In this case in addition to the 1s electron a 3p electron is excited. This excitation will be possible if the difference between the K-edge and the measured threshold energy reaches the electron binding energy of the 3p states added by an additional energy offset, where the offset is caused in the reduced screening of the system after the 1s excitation. The filling of the 1s hole occurs in the presence of the 3p hole.

[I] P. M. Platzman, Phys. Rev. B 40, 5883 (1989)

[2] A. F. Starace, Phys. Rev. A 25, 842 (1982)

[3] M. J. Druyvesteyn, Zeit. f. Physik 43, 707 (1927)

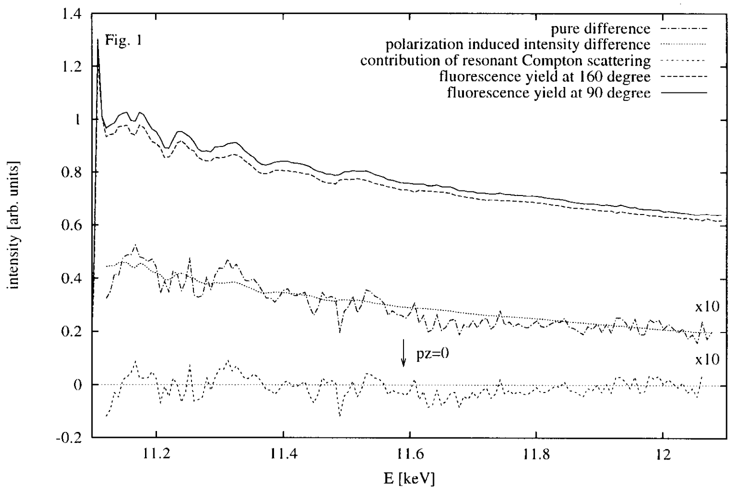

Fig. 1: Fluorescence yield at 90° (line) and 160° (dashed); polarization dependent difference of the fluorescence yield between 90° and 160° (dotted) compared to the pure difference (dashed dotted); contribution of Compton scattering and interference (short dashed).

Fig. 2: $K\beta_2$ fluorescence and satellites.

Fig. 3: Intensity of the second satellite scanning primary energy in inverse geometry at 160 ° (line) and scanning the analyzer energy at fixed primary energy at 90° and 160° (symbols). The arrow marks the threshold energy.