Comment on "X-Ray Compton-Raman Scattering from Atomic Inner-Shell Electrons"

In a recent Letter[1] Namikawa and Hosoya (NH) reported the observation of Compton-Raman scattering measured from Fe and Cu targets using 59.5-keV gamma rays from ^{241}Am source. The K-shell contribution was separated by a coincidence technique. Although the experiment seems to be correct, there are errors in the interpretation of the data.

The inelastically scattered spectra in NH's work were interpreted to include a Compton peak at 40.7 keV for Fe (39 keV for Cu), a false coincidence peak at 49 keV, a Raman peak just below the binding edge $\Delta E = E_b$, and a double-photon Thomson peak. The false coincidence peak was explained as due to the sequential Compton scattering, first in the sample and then in the x-ray detector which measures the energy of the recoil electron while the other detector measures the photon energy after two Compton scattering events. On the basis of Fig. 1 in NH's Letter (scattering angles of 77° and 90°) this gives final photon energies centered around 49.3 keV and electron recoil energies centered at 5.3 keV. The latter value is just outside the Fe window (5.4–7.7 keV) and quite far away from the Cu window (6.9–9.7 keV), but because of the electron momenta the recoil spectrum will be smeared. The large mismatch of energies makes the false coincidence peak very small in Cu measurement.

It is possible, however, to have false coincidences in such a way that the scattering in the sample is elastic and Compton scattering takes place in the x-ray detector. This produces a final photon spectrum centered at 53.3 keV and electron recoil energies around 6.2 keV. I measured the ratio of elastic to Compton scattering using a ^{241}Am source and a scattering angle of 77° (this corresponds to scattering to the x-ray detector in NH's experiment) and it was 14% for Fe and 17% for Cu. The electron recoil energy is just in the Fe window, which together with lower absorption strongly enhances this type of false coincidences. The peak at 53 keV interpreted as a combination of Raman and double-photon Thomson scattering in the Fe spectrum is therefore a result of false coincidences. The calculation of the exact position of this peak requires more information about the experiment (exact scattering angles, resolution smearing of the energy window cutting).

In the case of Cu the x-ray window cuts off the low-energy side of the recoil energy spectrum and this means a change in the shape and in the position of the false coincidence peak (the total energy is fixed). The window favors again elastic-Compton type of coincidences and two separate false coincidence peaks can be seen. The very low statistical accuracy makes it impossible to say whether there is more than one peak. An easy way to improve the experiment drastically would be to put a piece of lead between the two detectors which eliminates the sequential Compton scattering completely.

Another error in NH's Letter is related to the position of the Compton peak. They claim that the peak shifts by the amount of electron binding energy because of the failure of the impulse approximation. All experimental and theoretical evidence obtained so far, even in the case of strongly bound electrons,[2,3] indicates that the impulse approximation works surprisingly well.

By subtracting the two false coincidence peaks, one is left within the statistical error limits with a smooth $1s$ Compton profile and a cutoff at the binding edge, smeared by the detector resolution. I checked this by measuring the total Compton profile of Fe using the same geometry as NH but a stronger source and better energy resolution. After acquisition of enough counts the Fe K edge can be easily seen without any structure in it.

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