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Report:

We report the first direct observation of a resolved high momentum component in high resolution Compton profiles of Be measured using x-rays. These high momentum components which are result of the periodic lattice potential are previously seen only using positron annihilation technique. However, the use of high energy x-rays enables systematic temperature dependent studies over extensive range. Careful study of high momentum components yields information on electron-ion interaction which plays a crucial role in interpretation of electron-electron correlation in solids.

The effect of changing temperature in the Compton profiles is mainly due to expansion of the Be lattice and thus changing the Fermi momentum. The strenght of the electron-ion interaction changes with temperature via the Debye-Waller factor so that the strenght of the interaction and thus the intensity of the high-momentum components are expected to reduce as the temperature is increased. This is the first time the temperature dependence of the high momentum components have been studied directly.

In the experiment the Compton profiles of single crystal Be were measured with the scattering vector along the reciprocal lattice vector [110] in temperatures of 40, 300, 650 and 850 K using a cryostat and a heater environment. In the [110] direction the high momentum components are very well resolved. The room temperature profile was measured in both environments for comparison. We used monochromatized and horizontally focused x-rays with incident energy of 56 keV. The beam size was 200 μm horizontally and 5 mm vertically. The scattering angle was 173°. The spectra of Compton scattered radiation was measured using a scanning crystal spectrometer with a momentum resolution $\Delta p_z = 0.16$ a.u.

The data show clearly the change in lattice constant, and the differences in the width of the Compton profiles are well explained by the free and independent electron theory. The position and relatively intensity of the high momentum components, which originate from the inhomogeneity of the electron gas, are well reproduced by a LDA calculation. Their intensity and position show a small variation in intensity (but not in shape) so that the intensity decreases with increasing temperature, as would be expected, if the change of the electron-ion interaction is explained by the changes in Debye-Waller factor. However, as the Debye temperature of Be is 1000 K, changes occurring below this temperature are very small. Other solid state systems with lower Debye temperature have unfortunately no clear high momentum components in the Compton spectra, unlike Be.

Theoretical calculations of the Compton profiles including the temperature dependence of the electron-ion interaction strength are under progress.