ESRF

Experiment title:
High Resolution Compton Measurements on $LiNbO_3$ in an Alternating Electric Field

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HC-318

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Report:

The reported measurements on $LiNbO_3$ were intended to access complementary information about the behaviour of delocalized valence electron in alternating electric fields. Diffraction studies of the charge distribution, which essentially sample the localized core electrons, revealed already important structure changes and it was questionable to what extend one could obtain changes in the electron momentum distribution probed by Compton scattering experiments.

The measurements have been performed by means of the Compton spectrometer installed on beamline ID15 B. A monochromatic beam of 58 *keV was* focussed by the 311 Si-monochromator on the sample and a flux of 2.0 $\star 10^{11} ph/s/0.1\% BW/100 mA$ could be obtained in a spot of 0.3 $\star$ 0.75 mm^2. The scattering angle was 160° and with the 440 Ge-analyzer we could achieve 0.2 au. momentum resolution. The external electric field of 800 *V was* controlled by special electronics which switched the field and generated in addition a gate signal to be used as an external clock for the VME counter. The field alternated with cycles [+, O *V*, –,+, *O V*, –, *etc.].* With the spectrometer scans of the momentum distribution were performed with the smallest possible stepsize and for every position a preset number of alternating field cycles was read into 3 different counters. The sample was a tryst al of $3\star 3\ mm^2$ with a thickness of 0.186 mm. The external electric field was coupled into the tryst al by means of aluminum cathodes mounted on the larger surfaces and was thus oriented parallel to the c-direction of the crystal. We have measured directional profiles with the scattering vector oriented along this c-direction, 45° and 90° inclined to it. For the c-direction parallel to the scattering vector we measured first full scans of the complete Compton profile before we reduced the scanning range to the area of interest at small p_z –values. Like this we were able to increase the statistical accuracy of the measurement. Because Compton profiles are symmetric and one expects changes of the momentum distribution only for the valence electrons which have small momentum, the corresponding area in momentum space should still contain the most interesting features.

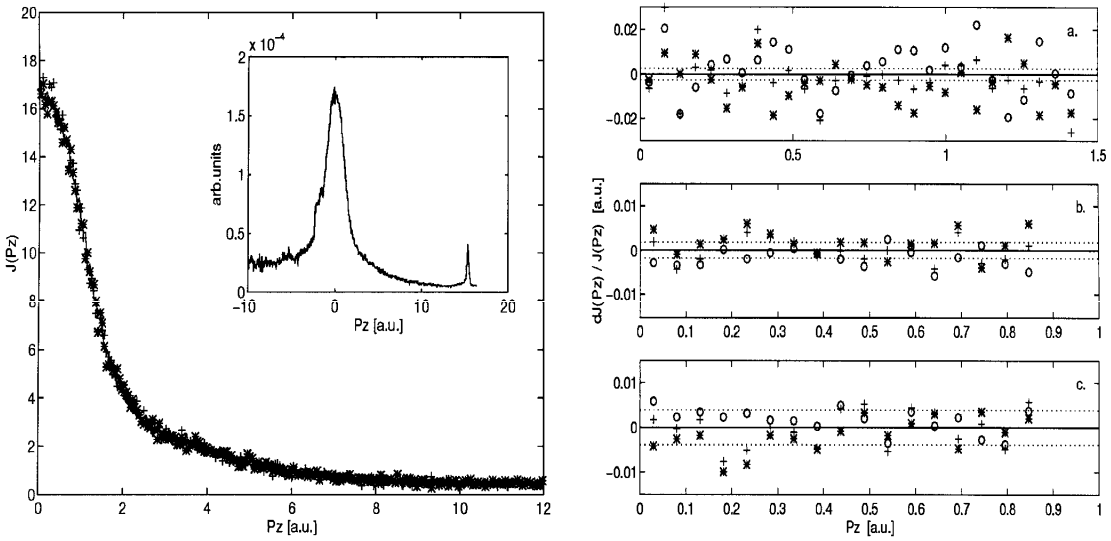

Figure : Left figure shows the Compton profile for pos.(solid line), zero(+) and neg.(*) electric field and a raw profile in the insert. The $\vec{K}$−vector is parallel to the external field. On the right side difference profiles for $\vec{K} \| \hat{c}$ *(a.),* $\vec{K} \vee^{45} \hat{c}$ *(b.),* $\vec{K} \perp \hat{c}$ *(c.) are* shown. +,*, o correspond to $('+' - '0\ V')/'+'$, $('+' - '-')/'+'$, $('O\ V' - '-')/'0\ V'$, resp. and dotted lines indicate the statistical error.

In the left part of the figure the Compton profile for $\vec{K} \| \hat{c}$ is shown for different directions of the electric field and in the insert a raw profile is given. The second column shows difference profiles between different directions of the external electric field for the 3 directional measurements $[\vec{E} \| \hat{c}; \vec{E} \vee^{45} \hat{c}; \vec{E} \perp \hat{c}]$. The range in momentum space corresponds to the scanning region for the later measurements and contains the highest statistical accuracy. In the raw data Compton profile one obtains in addition to the Compton peak at p_z = O and the elastic line at $p_z \approx$ 16 a structure at p_z = 1.0 au. which is due to a parasitic 511 reflection from the analyser tryst al reflecting the elastic line. Peak countrates of few 100 *cps* could be obtained and the shown Compton profiles result from a summation of all spectra with the same orientation and field direction. Background has been subtracted and the profiles have been normalized to the number of electrons in the corresponding moment urn range. The differences have been obtained from the Compton profiles by subtracting spectra for different field direction.

When evaluating the data no detectable effect was obtained for neither direction of $LiNbO_3$ which was out side the statistical errors mainly determined by counting st atistics. The counting statistics $\Delta N/N = \sqrt{2N}/N$ was estimated to be 0.26% $(\vec{K} \| \hat{c})$, 0.18% $(\vec{K} \vee^{45} \hat{c})$ and 0.39% $(\vec{K} \perp \hat{c})$. The numbers determine also the maximum size of the effect obtainable. From the figure one can see that for the direction $\vec{K} \| \hat{c}$ the error is somewhat larger, this is probably due to problems with the monitoring during the scan.