Inverse Compton for Compton

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Sagamore Conference is a conference on electron densities: charge, spin and momentum. This is still the case, although the sessions no more carry those titles. This talk goes back to basics, but from a new direction.

The most direct probe of electron momentum density (EMD) is Compton scattering. Compton profile (CP) is the projection of EMD on the scattering vector, and it is extracted from the energy spectrum of the inelastic scattering. 3D-EMD is reconstructed from a sufficient number of directional EMDs.

Compton scattering is a sensitive probe of the outer electron states, i.e. chemical bonding. The limitation is due to EMD being that of all electrons, so that a theoretical model is needed for separation of the atomic contributions and to link EMG to charge density ECD. The interplay of Compton scattering experiments and theoretical calculations has been essential for understanding condensed matter phenomena and theoretical foundations.

Compton scattering experiments at synchrotron radiation (SR) laboratories started a new era. However, there are only a few dedicated beamlines, and the experiments are time-consuming. The experimental accuracy of CPs should be on the 0.1% level, and together with demanding theoretical calculations, this has kept the number of EMD studies by Compton scattering rather limited.

This work outlines a probable revival of Compton scattering studies. The bottle-neck of too few experimental facilities will open with the advent of compact SR sources. In the so-called inverse Compton process a laser pulse collides head-on with an ultra-relativistic electron bunch and is back-scattered as hard x-rays. The radiation cone has an opening of a few mrad, and the energy bandwidth is a few percent. At the moment, there is one compact Compton source (CCS) available commercially, and several are being designed and built. The projected total fluxes are $10^{12}$to 10^{12} ph/s, and an order of magnitude less in collimated beams. In this work the design parameters of ThomX (Orsay, France) are used for estimates of beam intensity.

The x-ray beam from a CCS is ideal for a dispersion-compensating Compton spectrometer. The entire beam and most of the energy band are utilized. The x-ray optics is based on use of bent Laue crystals as monochromators and analyzer. By crossed crystals a narrow horizontal beam with energy gradient is focused on the sample, and with a matching gradient at the analyzer exact dispersion compensation is achieved. The incident flux on the sample from ThomX operating at 80 keV is estimated to be about 10^{11} ph/s in a bandwidth of 3%. It is inferred from earlier work that a Compton profile would be acquired with an average count rate of 10^{3} cps and momentum resolution better than 0.1 atomic units.

References:

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