High-purity polarimetry with hard x-rays

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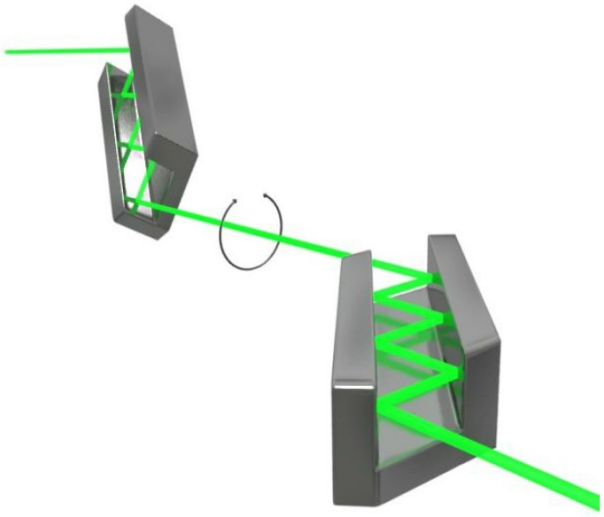
Polarimetry belongs to the most sensitive methods in the visible spectral range and forms the basis of a countless number of applications. In x-ray science, polarimetry becomes increasingly important, as well. By increasing the purity of linear polarization and, thus, the sensitivity of x-ray polarimeters to the physical limits, a variety of fundamental physical questions can be addressed. One of these is the detection of vacuum birefringence induced by an intense electro-magnetic field – a fundamental consequence of quantum electrodynamics (QED). In addition, quantum optical phenomena in the x-ray range, tiny electronic anisotropies in crystals and the investigation of the evolution of magnetic fields in plasma are examples where high-sensitive polarization analysis is indispensable.

By improving the performance of silicon channel-cut crystal polarizers, we obtained an extreme polarization purity of 2.4×10^{-10} in the last years [1], which makes tiniest polarization changes measurable. Even the optical activity of a sugar solution, which lead to a small rotation of the polarization plane of 4 μrad, become measurable [1]. As the first synchrotron in the world, Petra III in Hamburg offers a permanent x-ray polarimeter for their users. Soon, there will be a high-purity polarimeter available at the European XFEL as well. Besides silicon, germanium and quartz crystals can be used for high-purity x-ray polarimetry, too and open new wavelength ranges that can be investigated. Another promising candidate especially for XFEL applications is diamond. Recently, we demonstrate that two precisely aligned diamond crystals, as a so-called quasi-channel-cut, can realize purities in the order of 10^{-10} as well [2]. These high degrees of linear polarization offer unique possibilities for the investigation of open fundamental physical questions.



Sketch of a high-purity x-ray polarimeter consisting of two channel-cut crystals.

References

[1] B. Marx, *et al*., High-precision x-ray polarimetry, PRL 110, 254801 (2013).

[2] H. Bernhardt, *et al.*, High purity x-ray polarimetry with single-crystal diamonds, APL 109, 121106 (2016).