Demonstration of Faraday rotation using high order harmonics for ultrafast demagnetization applications

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Abstract

Up to recent years, synchrotron radiation facilities and free electron lasers were used as a tool for implementing magneto-x-ray spectroscopies in order to study magnetic phenomena and the properties of the magnetic materials. High order harmonic generation (HHG) arises as a new source to accomplish these studies [1], beneficiating from free jitter between pump and probe beams, polychromaticity to probe various edges in the same time, and a few *fs* time resolution. Yet, several techniques to evaluate the magnetization require elliptical polarized light. Even if recent solutions have been found to get highly elliptical harmonics, it remains much easier to handle linearly polarized harmonics.

Here we present the demonstration of the Faraday rotation effect in resonance introduced by a Cobalt magnetic element at 60 eV. We show that the magnetization can be measured using linearly polarized harmonics. The Faraday rotation is a magneto-optical phenomenon that rotates the polarization of light in transmission of a magnetic sample when a magnetic field is applied perpendicular to its surface. The incident linearly polarized light can be decomposed into two circularly polarized waves, having equal amplitude but opposite helicity. And for each helicity the dephasing of the sample is different, generating a rotation of the polarization axis [2]. We then measured the variation of the 60 eV HHG signal after a XUV analyzer, corresponding to the rotation introduced by the sample.

Experimental considerations

The experiment was conducted at Laboratoire d'Optique Appliquée (LOA) using a 5 KHz laser system with a duration of 30 fs and a wavelength of 800 nm. In our configuration, the sample is surrounded by four permanent magnets and its magnetic field as well as the incident light are both normal to the sample's surface. The sample is a CoDy (50nm thickness). A multilayer, which selects a small range of harmonics including the one at 60eV, is placed after the sample, followed by a SiO_2 polarizing mirror (Brewster's angle at 60 eV) that reflects the beam into the CCD camera. To easier detect the Faraday effect, a half wave-plate was used to rotate the harmonic polarization after the sample in order to extinguish the signal with the analyzer on the camera. When the magnetization on the sample is inverted, by rotating the four permanent magnets on 180°, a rotation of the polarization axis occurs, introducing a significant vertical component and, consequently, an increase of the reflection on the SiO_2 mirror.

Measurements

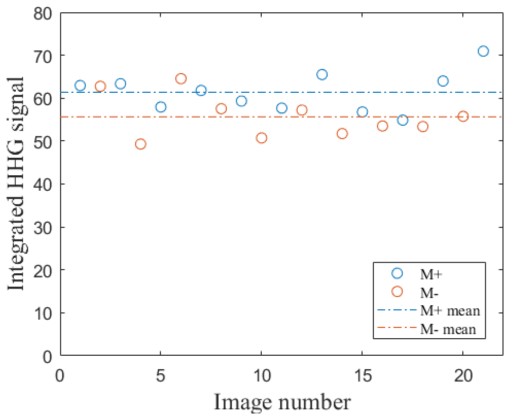

Fig. 1: Integrated HHG signal for consecutive alternated magnetic field directions.

Due to the sample (about 99.99%) and the low reflectivity of the SiO_2 mirror, the HHG signal is weak on the camera but increases clearly when rotating to the opposite magnet direction (M+). The analysis of the CCD images allowed determining an effect of 9.20% (Fig. 1). Actually, other harmonics than the 60 eV one were transmitted (especially lower harmonic orders) polluting the measurement. In conclusion, by more accurately isolating the desired harmonics, the Faraday rotation effects could be much higher.

References

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