Ultrafast demagnetization and electronic processes in cobalt trigerred by x-ray photons

Konrad J. Kapcia,[1,2] Victor Tkachenko,[3,2] and Beata Ziaja[2,4]

[1] *Institute of Spintronics and Quantum Information, Faculty of Physics, Adam Mickiewicz University, Uniwersytetu Poznańskiego 2, 61-614 Poznań, Poland*

[2] *Center for Free-Electron Laser Science CFEL, Deutsches Elektronen Synchrotron DESY, Notkestr. 85, 22607 Hamburg, Germany*

[3] *European XFEL, Holzkoppel 4, 22869 Schenefeld, Germany*

[4] *Institute of Nuclear Physics, Polish Academy of Sciences, W.E. Radzikowskiego 152, 31-342 Kraków, Poland*

We investigated the role of electronic excitation, relaxation and transport processes in X-ray induced ultrafast demagnetization of magnetic multilayer systems. In what follows, we report on the results obtained with the newly developed modeling tool, XSPIN, which enables nanoscopic description of electronic processes occurring in X-ray irradiated ferromagnetic materials [1,2]. With this tool, we have studied the specific response of cobalt/platinum (Co/Pt) multilayer system irradiated by an ultrafast XUV pulse at the M-edge of Co (photon energy around 60 eV) [1]. It was previously studied experimentally at the FERMI free-electron-laser facility, using the magnetic small-angle X-ray scattering technique (mSAXS) [3]. The XSPIN simulations show that the magnetic scattering signal from cobalt decreases on the femtosecond timescales considered due to electronic excitation, relaxation and transport processes both in the cobalt and in the platinum layers. The signal decrease scales with the increasing fluence of incoming radiation, following the trend observed in the experimental data. Similar observations [2] were also made for the recent demagnetization data [4] from magnetic multilayer systems recorded at the L-edge of Co (Co/Pd multilayer system, photon energy about 778 eV), which are also briefly discussed here. Confirmation of the predominant role of electronic processes for X-ray induced demagnetization in the regime below the structural damage threshold, achieved with our theoretical study, is a step towards quantitative control and manipulation of X-ray induced magnetic processes on femtosecond timescales.

References:

[1] K. J. Kapcia, V. Tkachenko, F. Capotondi, A. Lichtenstein, S. Molodtsov, L. Müller, A. Philippi-Kobs, P. Piekarz, B. Ziaja, npj Computational Materials **8**, 212 (2022).

[2] K. J. Kapcia, V. Tkachenko, F. Capotondi, A. Lichtenstein, S. Molodtsov, L. Mueller, A. Philippi-Kobs, P. Piekarz, B. Ziaja, Phys. Rev. B **107**, 094402 (2023).

[3] A. Philippi-Kobs et al., preprint at https://www.researchsquare.com/article/rs-955056/v1 (2021).

[4] B. Wu et al., Phys. Rev. Lett. **117**, 027401 (2016).

Supported by the Polish National Agency for Academic Exchange in the frame of the Bekker programme (PPN/BEK/2020/1/00184).