Magnetic X-ray scattering at Free Electron Laser (FEL) sources

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The structure and dynamics of magnetic nanosystems is of both, fundamental and technological interest. Ideally, one would like to probe magnetisation dynamics on a time scale of 100 femtoseconds (fs), with nanometre spatial resolution, while being able to do the measurements element-specifically in order to account for the complex composition of actual magnetic media. Simultaneous fulfilment of these requirements mandates for ultrafast magnetic scattering experiments using flashes of resonantly tuned soft X-rays that can be anticipated given the current construction of X-ray free-electron lasers (FEL) in Stanford, CA, Hyogo, Japan and Hamburg, Germany. At present the world's most powerful FEL, FLASH in Hamburg provides uniquely intense coherent short pulses in the EUV energy range with the shortest fundamental wavelength λ=6.1 nm. However, lasing is also observed at higher harmonics of the fundamental FEL mode, as it was shown recently. Using the fundamental wavelength λ=7.97 nm we were able to detect the fifth harmonic at 1.59 nm with an average energy of 3.5 nJ which constitutes the shortest wavelength ever demonstrated at an FEL. This wavelength corresponds to the Co L_3 absorption edge and enabled us [1] to perform the first resonant magnetic scattering experiment using FEL pulses of about 20 fs duration.

[1] C. Gutt, l.-M. Stadler, S. Streit-Nierobisch, A.P. Mancuso, A. Schropp, B. Pfau, C.M. Günther, R. Könnecke, J. Gulden, B. Reime, J. Feldhaus, E. Weckert, I.A. Vartaniants, O. Hellwig, F. Staier, R. Barth, M. Grunze, A. Rosenhahn, D. Stickler, H. Stillrich, R. Frömter, H.P. Oepen, M. Martins, T, Nisius, T. Wilhein, B. Faatz, N. Guerassimova, K. Haonkavaara, V. Kocharyan, R. Treusch, E. Saldin, S. Schreiber, E.A. Schneidmiller, M.V. Yurkov, S. Eisebitt and G. Grübel, *Phys. Rev. B79*, 212406 (2009)