Spatially and time-resolved x-ray detected ferromagnetic resonance to study dynamic magnetic properties of micro-magnets

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The substitution of electrons by quasi-particles such as magnons is of a great importance for potential alternative developments in future computing technologies. A prerequisite for such magnonic devices are well-investigated and understood properties, and thus the possibility to control their behavior. The scope of our research is the investigation of magnetization dynamics in confined microstructures with unprecedented spatial and temporal resolution. By using lithographically fabricated micro resonators it had become possible to measure ferromagnetic resonance (FMR) of micron-sized samples, however spatially resolved information had to rely on micro-magnetic simulations [1]. In a next step these micro resonators were combined with scanning transmission x-ray microscopy (STXM) using a time synchronization scheme between the x-ray pulses of the synchrotron and the microwave excitation (STXM-FMR). The STXM-FMR setup enables the visualization of the high frequency magnetization dynamics in the GHz regime with a high lateral resolution of nominally 35 nm [2]. First test experiments on a prototypical sample consisting of two perpendicular Permalloy (Py) micro stripes 5x1x0.03 μm^3 demonstrated the feasibility [3] and careful control experiments were made to verify the magnetic nature of the observed dynamic contrast in STXM-FMR [4].
Here, I will introduce the basic principles of STXM-FMR and the underlying experimental techniques. This will be complemented by and overview on selected results to illustrate the nature of the dynamic magnetic contrast and recent experiments where we directly observe uniform and inhomogeneous magnetic excitation modes of the Py stripes. The observed spatial distribution of the excitations matches micro-magnetic simulations rather well. In addition it is found that the inhomogeneous excitations are not pure standing spin waves but they move in space and the movement depends on the mutual positioning of the stripes.

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