Coherent Resonant Soft X-Ray Scattering from Magnetic Domain Patterns

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In coherent x-ray scattering, a sample volume smaller than the coherence volume of the incident x-ray beam is illuminated. As a consequence, the scattering pattern contains a fine structure called "speckle", which is due to the fact that radiation scattered at different points in the sample can interfere. The speckle fine structure contains information about the individual spatial arrangement in the sample, which is beyond the average, statistical properties obtained in incoherent scattering experiments. Oversampling of the diffraction pattern has been mathematically shown to be a possible approach to overcome the phase problem, which has to be solved in order to extract the spatial information from the experimental data [1]. Recent experiments exploiting soft x-ray charge scattering from gold dots have demonstrated the viability of this approach in reconstructing the real space structure of submicron objects [2].

In this work, we are trying to lay the foundations in order to extend this concept to the investigation of magnetic domain patterns. Such patterns can be probed by resonant magnetic scattering. Circular and linear x-ray dichroism give rise to magnetization dependent contributions to the scattering cross-section and can be used as a contrast mechanism for coherent small angle scattering. We present first reconstruction results on worm domain structures in Co/Pt multilayers with perpendicular magnetic anisotropy.

The speckle imaging approach is of particular interest for future time resolved studies involving femto second x-ray pulses from a free electron laser. As a photon-in photon-out technique it has several advantages over electron based approaches, in particular, space charge restrictions are of no concern. An advantage over other photon imaging techniques is that no sophisticated optical components like zone plates are necessary to obtain nanometer spatial resolution.

[1] R. Barakat, G. Newsam, J. Math. Phys. 25, 3190 (1984)
[2] J. Miao, P. Chararlambous, J. Kirz, D. Sayre, Nature 400, 342 (1999)