Resonant X-ray Scattering from Magnetic Multilayers

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In this talk I shall describe two ways in which resonant X-ray scattering on XMaS has provided new understanding of the properties of magnetic multilayers.

Previous attempts to study induced spin-density waves in the spacer layers of multilayers using resonant X-ray scattering had been unsuccessful, but this was achieved for the first time on ID20 using Nd/Pr multilayers, where it was possible to investigate the magnetism of the Nd and Pr components separately. Energy scans revealed strong magnetic resonances at the Nd and Pr L_{II} edges, but with shoulders at higher energies. I shall describe how measurements on XMaS have allowed us to understand the anomalous line shape at these edges. The wave-vector transfer dependence of the scattering shows that both components of this resonance are due to dipolar transitions from the *2p* core levels to the *5d* bands. This clearly demonstrates that we are directly measuring the conduction-electron spin-density wave responsible for the propagation of magnetic order. The structure of the L_{II} resonance is believed to arise because the width of the *5d* band is broad in comparison to the inverse core hole lifetime.

The interactions between the ferromagnetic and antiferromagnetic blocks in Fe/Mn multilayers are of great technological interest since such interactions are responsible for the exchange biasing in spin valves. Theory predicts that the Mn should form either an antiferromagnetic structure with spins in the same direction as the Fe, or a helical structure. The extraordinary result obtained using neutron diffraction is that the Mn orders with a simple antiferromagnetic structure, but with spins pointing along the growth direction perpendicular to those of Fe. We have studied the interfacial structures using anomalous X-ray diffraction on XMaS. Fe/Mn multilayers have a one-electron contrast and the diffraction harmonics are, therefore, very sensitive to the small changes to the scattering factors at the Fe and Mn K edges. The results show that the interfaces contain terraces, leading to a frustration in the exchange interaction between Fe and Mn that can explain the observed magnetic ordering in the Mn.