# EXPLOITING COHERENCE: 3D MAGNETIC IMAGING

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Three dimensional magnetic systems promise significant opportunities for applications, for example providing higher density devices and new functionality associated with complex topology and greater degrees of freedom [1,2]. For the experimental realisation of these new properties, appropriate characterisation techniques are required to determine both the three-dimensional magnetic structure, and its response to external excitations. In this talk, I will describe how we have made use of coherent X-rays to characterize the three-dimensional structure of magnetic systems at the nanoscale.

In particular, we have developed X-ray magnetic nanotomography [3] to access the three-dimensional magnetic configuration at the nanoscale. In a first demonstration, we have determined the complex three-dimensional magnetic structure within the bulk of a micrometre-sized soft magnetic pillar and observed a magnetic configuration that consists of vortices and antivortices, as well as Bloch point singularities [3].

In addition to the static magnetic structure, the dynamic response of the 3D magnetic configuration to excitations is key to our understanding of both fundamental physics, and applications. With our recent development of X-ray magnetic laminography [4,5], it is now possible to determine the magnetisation dynamics of a three-dimensional magnetic system [5] with spatial and temporal resolutions of 50 nm and 70 ps, respectively.

A final challenge concerns the identification of nanoscale topological objects within the complex reconstructed magnetic configurations. To address this, we have recently implemented calculations of the magnetic vorticity [6,7], that make possible the location and identification of 3D magnetic solitons, leading to the first observation of magnetic vortex rings [7].

These new experimental capabilities of X-ray magnetic imaging open the door to the elucidation of complex three-dimensional magnetic structures, and their dynamic behaviour. In the coming years, 3D magnetic imaging will benefit significantly from advances in synchrotron radiation, with associated increases in coherent flux leading to higher spatial resolutions, as well as higher throughput for in situ measurements.

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