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Magnetic phase transitions, symmetry and representation analysis of magnetic structures.

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The transition from a paramagnetic phase to long range magnetically ordered crystal, a symmetry breaking transition, will be presented in the context of the Landau theory of phase transitions. We will discuss how to describe a magnetically ordered lattice, the concept of order parameter(s) and the symmetries required to fully characterize the magnetic state(s). The full magnetic symmetry, and magnetic space groups, will be introduced and I will review the use of online tools (Bilbao Crystallographic Server ¹, the Isotropy Software²) which greatly help in deriving the symmetry-allowed magnetic structures. We will discuss the formation of different domains (inversion, S-domains, k-domains, chirality domains.....) due to the loss of different symmetries and understand how complex magnetic arrangements can relate to physical phenomena such as ferroelectricity. I will present a number of examples of magnetic structures that have been determined by scattering techniques (in bulk).

- 1) M. I. Aroyo, J. M. Perez-Mato, D. Orobengoa, E. Tasci, G. de la Flor, A. Kirov "Crystallography online: Bilbao Crystallographic Server" *Bulg. Chem. Commun.* **43(2)** 183-197 (2011). [Scopus Web of Science](#)
- 2) B. J. Campbell, H. T. Stokes, D. E. Tanner, and D. M. Hatch, "ISODISPLACE: An Internet Tool for Exploring Structural Distortions." *J. Appl. Cryst.* **39**, 607-614 (2006).