# Thermodynamics and phase transitions in magnetic systems

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As William Gilbert noted in his 1600 treatise *De Magnete*,[1] magnetic order is found below some critical temperature. But why and how does magnetic order emerge from disorder, or indeed from another ordered state? Such questions are at the heart of the study of magnetic phase transitions.

This lecture will discuss the thermodynamics of phase transitions, applied to the case of magnetic materials. We will examine mean field approaches including Landau theory, using the limitations of such approaches to motivate a discussion of Ginzburg-Landau theory and the roles of fluctuations and of spin waves. The material presented here will inform the discussion of magnetic phase transitions for room temperature magnetic cooling in the *Magnetocaloric materials* lecture.

There are a number of suitable references on the topic of thermodynamics and phase transitions, not just in magnetic materials,[2,3,4] but also more generally.[5,6,7] A selection is given below.

## References

1. William Gilbert, *De Magnete* (Peter Short, London, 1600). Searchable English version available at http://www.gutenberg.org/files/33810/33810-h/33810-h.htm
2. N.W. Ashcroft and N.D. Mermin, *Solid State Physics* (Holt-Saunders Int., New York, 1976) Chapter 33.
3. S.J. Blundell, *Magnetism in Condensed Matter* (Oxford University Press, Oxford, 2001) Chapters 5-8.
4. J.M.D. Coey, *Magnetism and Magnetic Materials* (Cambridge University Press, Cambridge, 2010) Chapters 5 and 6.
5. P. M. Chaikin, and T. C. Lubensky *Principles of Condensed Matter Physics* (Cambridge University Press, Cambridge, 2000).
6. *The Physics of Phase Transitions – Concepts and Applications*, Ed. P. Papon, J. Leblond and P.H.E. Meijer (Springer-Verlag, Berlin Heidelberg, Germany, 2006) Chapter 7.
7. H. Nishimori and G. Ortiz, *Elements of Phase Transitions and Critical Phenomena* (Oxford University Press, Oxford, 2010) Chapters 1 and 2.