Phase Transitions

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Magnetic phase transitions are still a rich field of research as they are relevant for both a better fundamental understanding and for practical applications. There exist many types of magnetic phase transitions. The most prominent ones are order-disorder transitions. For a ferromagnet we take the magnetization and for an antiferromagnet the staggered magnetization as order parameter. In the temperature region near an order-disorder phase transition of second order the order parameter continuously drops to zero and there is a singularity in its temperature derivative. A first order phase-transition is characterized by a discontinuous drop of the order parameter. Strictly speaking the description given above is only true for an infinite system. In real systems we never observe discontinuities but very steep changes and in general we speak about a critical region of the phase transition. Order-order phase transitions are also of great interest as they give the opportunity to elucidate the role and strength of competing magnetic interactions.

We shall discuss how one can discriminate first and second order phase-transitions experimentally on real systems. Also we shall discuss how history dependence that is intimately connected with first order phase transitions may affect measurements and how one can avoid artifacts in results.

In the tutorial a few examples of magnetic phase transitions shall be discussed. Special attention will be given to combined magneto-structural and magneto-elastic phase transitions. These phase transitions are currently receiving great attention as these may be utilized as actuators, sensors, and for magnetocaloric applications. We shall discuss the rich phase diagram of compounds based on MnCoGe [1, 2]. MnCoGe exhibits a martensitic transition at elevated temperatures and a magnetic transition near room temperature. These two transitions can be tuned to coincide. We shall discuss how to couple these transitions and the information we can extract from the effect of pressure on these phase transitions.

A special type of first order phase transition is observed in some Fe_2P based alloys. These materials exhibit a first order magnetic phase transition without change of crystal symmetry and most astonishingly without volume change.

1) N. T. Trung, L. Zhang, L. Caron, K. H. J. Buschow and E. Brück, *Appl. Phys. Lett.* **96** 172504 (2010).

2) N. T. Trung, V. Biharie, L. Zhang, L. Caron, K. H. J. Buschow and E. Brück, *Appl. Phys. Lett*. **96**, 162507 (2010).