Introduction to the Investigation of Magnetism and Superconductivity using the Muon Spin Rotation (µSR) Technique

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Magnetism and superconductivity are key elements in the electronic phase diagram of all unconventional superconductors, such as the high-$T_c$ cuprates, heavy-fermion, organic and Fe-based superconductors. Muon spin rotation/relaxation/resonance (µSR) is a powerful tool for locally studying the small moment antiferromagnetic and superconducting phases of high-$T_c$ materials as a function of a control parameter such as doping or pressure. In this context, it is of special advantage that µSR, as a local probe, is sensitive to both the superconducting and magnetic volume fractions and to the respective order parameters, that fundamental microscopic parameters such as the magnetic penetration depth can be determined absolutely, and that µSR is extremely sensitive to small-moment and short-range magnetic order. Therefore µSR is widely recognized as one of the key techniques for investigating fundamental magnetic and superconducting properties, as well as for testing the microscopic competition or coexistence of magnetic and superconducting ground states.

In my talk, I will give a detailed introduction to the µSR technique with the emphasis on the examination of magnetic and superconducting properties. I will illustrate the capabilities of the technique by giving examples from cuprates, cobaltates, pnictides and other topical materials. If time allows, I shall introduce the worldwide unique low energy µSR technique which enables us to investigate magnetic and superconducting properties on a nanometer scale in thin films and multilayers also.