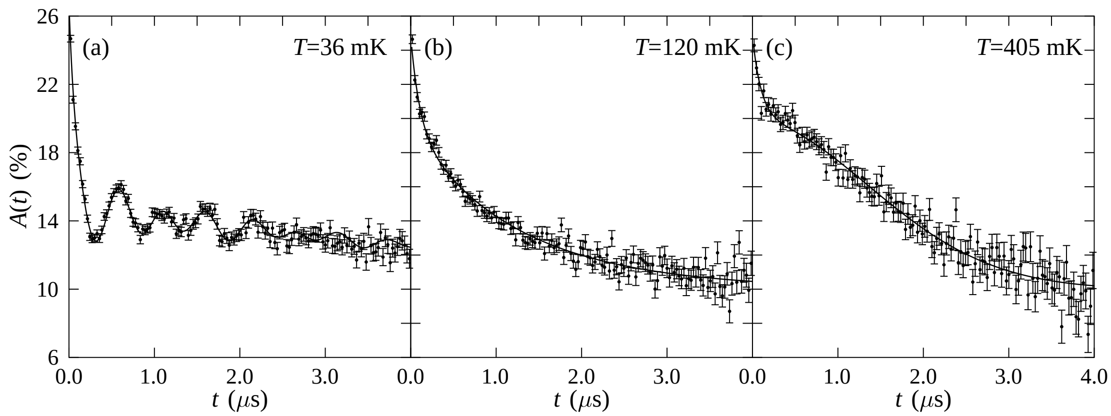
Muons in the study of magnetism

Stephen J. Blundell

Oxford University Department of Physics, Clarendon Laboratory,
Parks Road, Oxford OX1 3PU, United Kingdom



A positive muon is a spin-$1/2$ particle. Beams of muons with all their spins polarized can be prepared and subsequently implanted in various types of condensed matter. The subsequent precession and relaxation of their spins can then be used to investigate a variety of static and dynamic effects in a sample and hence to deduce properties concerning magnetism, superconductivity and molecular dynamics. The experimental technique is called muon-spin rotation (μSR) [1,2] and can be carried out in laboratories which possess a proton cyclotron or synchrotron. In Europe, experiments can be done either at ISIS (UK), which is source of pulsed muons, or at the Paul Scherrer Institute (Switzerland), a continuous source of muons. I will describe how muons can be used to study local magnetic properties of a variety of magnetic materials, including frustrated oxides and molecular magnets [3], and describe the sort of information which can be obtained from muon studies. I explain how muon-spin rotation (μ^+SR) can be particularly effective in determining the onset temperature of three-dimensional ordering in low-dimensional molecular magnets, even when the low dimensionality means that this transition is masked in data from bulk thermodynamic probes such as heat capacity measurements. I will illustrate the use of μSR in low-dimensional systems with data on various copper-based magnets, including copper pyrazine dinitrate, $Cu(C_4H_4N_2)(NO_3)_2$, which orders below 0.107 K (see above) [4], and also for the organic radical-ion salt DEOCC-TCNQF$_4$ [5] which appears to be one of the most ideal examples of the one-dimensional $S = \frac{1}{2}$ Heisenberg antiferromagnets yet discovered.

[1] S. J. Blundell, Contemp. Phys. **40**, 175, (1999) [available as cond-mat/0207699]

[2] S. J. Blundell, Chem. Rev. **104**, 5717, (5736)

[3] S. J. Blundell and F. L. Pratt, J. Phys.: Condens. Matter **16**, R771, (2004)

[4] T. Lancaster, S. J. Blundell, M. L. Brooks, P. J. Baker, F. L. Pratt, J. L. Manson, C. P. Landee and C. Baines, Phys. Rev. B **73**, R020410, (2006)

[5] F. L. Pratt, S. J. Blundell, T. Lancaster, C. Baines and S. Takagi, Phys. Rev. Lett. **96**, 247203, (2006)