Investigating quantum spin liquids using implanted muons

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A quantum spin liquid phase is an intriguing possibility for a system of strongly interacting magnetic units, in which the usual magnetically ordered ground state is avoided due to the combined effects of magnetic frustration and strong quantum fluctuations[1]. Although this idea has stimulated theorists for many years, good model materials for experimental study have generally been rather lacking. Recently however, some interesting new examples have emerged in the form of triangular-lattice Mott-insulator molecular systems[2]. A specific case is κ-$(BEDT\text{-}TTF)_2Cu_2(CN)_3$ which has an almost isotropic triangular magnetic lattice of spin ½ BEDT-TTF dimers that provides a prime example of spin liquid behaviour. Despite having a high temperature exchange coupling of 250 K, no obvious signature of conventional magnetic ordering is seen down to 20 mK. It has been shown using the highly sensitive muon spin rotation technique that applying a small magnetic field to this system at low temperatures produces a quantum-phase-transition between the low-field spin liquid phase and an antiferromagnetic phase with a strongly suppressed moment[3]. This can be described as Bose-Einstein condensation of spin excitations with an extremely small zero-field spin gap. At higher fields a second transition is found that suggests a magnetic theshold for the deconfinement of spin excitations. From these studies the low-temperature magnetic phase diagram is revealed and characteristic critical properties are measured. These results are closely compared with current theories and with comparable data on another molecular quantum spin liquid, $EtMe_3Sb[Pd(dmit)_2]_2$, giving further insight into the nature of these spin liquids.

[1] L. Balents, *Nature* **464**, 199 (2010).
[2] B.J. Powell and R.H. McKenzie, *Rep. Prog. Phys.* **74**, 056501 (2011).
[3] F.L. Pratt *et al.*, *Nature* **471**, 612 (2011).