SPECIFIC HEAT AND MAGNETOCALORIC EFFECT IN $NiCl_2$-$4SC(NH_2)_2$

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We have developed a new calorimeter for the 20 Tesla DC superconducting magnet at NHMFL. The calorimeter operates in a dilution refrigerator between 50 mK and 4 K in fields up to 20 Tesla, and uses a heat pulse relaxation technique. Measurements of specific heat and the magnetocaloric effect are in progress for $NiCl_2$-$4SC(NH_2)_2$, which is a potential candidate for Bose Einstein Condensation (BEC) of spins. The S = 1 Ni spin triplet ground state is split by the atomic anisotropy into a lower S = 0 state and a higher S = 1 state. Applied magnetic fields parallel to the tetragonal axis reduce the splitting until a level crossing occurs at H = 2 T. Between H = 2 T and H = 12 T, field-induced long range order occurs below T = 1 K. In other similar compounds, this long range order has been interpreted in terms of a BEC of triplet spins. Unlike many previous BEC candidates, DTN exhibits a strong single axis anisotropy with rotational symmetry in the ab plane, which allows for the conservation of magnons. The single crystal samples are grown by A. Paduan-Filho at the Instituto de Fisica, Universidade de Sao Paulo, Brazil and measured at NHMFL. Preliminary measurements of the magnetocaloric effect are on this compound are shown in Fig. 1.

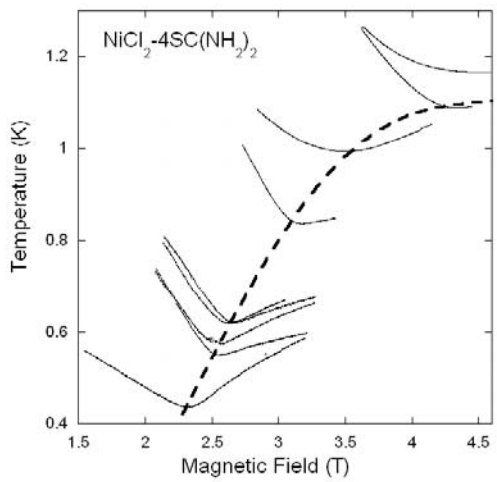

Fig. 1 Adiabatic temperature sweeps as a function of magnetic field of single crystalline $NiCl_2$-$4SC(NH_2)_2$ oriented with the magnetic field parallel to the tetragonal c-axis. Dashed lines indicate the estimated onset of field-induced long-range order.

The sample is mounted on a sapphire plate in a quasi-adiabatic environment, and the temperature of the sample is monitored as a function of applied magnetic field by a RuO_2 field-calibrated thermometer. A significant cooling effect is observed as the magnetic field is increased from 0 until the onset of long range magnetic order. This can be attributed to an increase in magnetic entropy as the energy splitting between the S = 1 and the S = 0 state is reduced. A minimum is observed in the temperature vs. field curve where the energy levels become degenerate and long range order sets in. The phase diagram, determined by this method, indicated by the dashed line in Fig. 1, is in good agreement with that determined from magnetization measurements [1]. More measurements are underway to determine the phase diagram in greater detail and explore the specific heat near the transition to long-range order.

Acknowledgements

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References

[1] Paduan Filho, A. et al., Phys. Rev. B **69**, 02045R (2004).