LOW TEMPERATURE THERMAL CONDUCTIVITY OF $NiCl_2$-$4SC(NH_2)_2$ UP TO 14 T

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Spin gap compounds can exhibit many interesting quantum effects that are only be realized at low temperatures and high magnetic fields. One of the most exciting possibilities is that these spin gap compounds may be magnetic analogs of the Bose Einstein Condensate (BEC). Thermal conductivity, κ, measurements may provide a more direct probe of the BEC state, e.g. κ of superfluid liquid ^{4}He is extremely large below the BEC λ-transition. Therefore, we have developed a probe to measure κ using the steady-state method to investigate the BEC state in spin gap compounds. This is the first time that measurements of κ using this method have been performed at NHMFL-LANL.

Below we present preliminary measurements on $NiCl_2$-$4SC(NH_2)_2$ in Fig. 1. This material possesses a spin gap of approximately 1 K [1]. At low temperatures and high magnetic fields (2-12 T), it appears that this compound undergoes field induced magnetic ordering as the spin gap is closed. The resulting phase diagram in the *T*-*H* plane resembles that of other magnetic BEC candidates, such as $TlCuCl_3$ and $BaCuSi_2O_6$, but the regime where a BEC is suspected to occur is located at a much lower, and therefore more convenient, magnetic field range. The data presented below were taken from 2-70 K, up to 14 T, in the 15 T DC superconducting magnet at NHMFL-LANL.

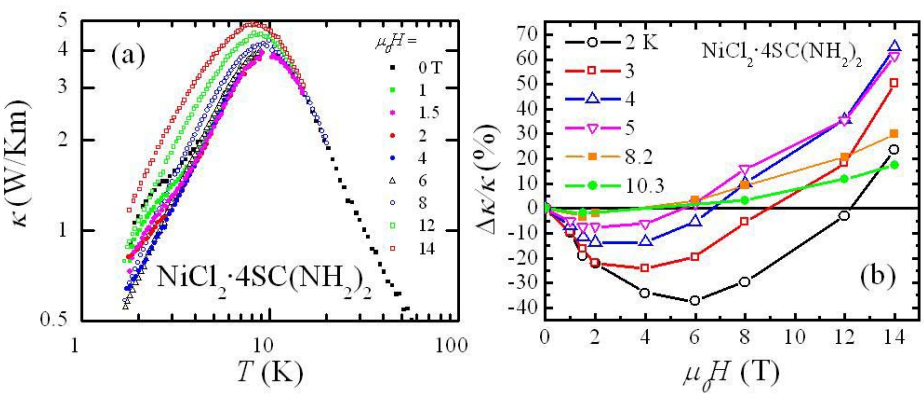

Fig 1 (a) Thermal conductivity of $NiCl_2$-$4SC(NH_2)_2$ versus temperature a various fields up to 14 T. (b) Fractional change in κ relative to zero field as a function of field.

Figure 1(a) shows the variation of κ as a function of temperature, at various fixed fields. The temperature range of this data is above the field-induced ordering temperature (~ 1 K), nevertheless, there are pronounced field-induced changes in κ. This behavior may be the result of the interaction between phonons and the spin gap. Quantum excitations may also play a role. Such interactions have non-trivial implications for the possible BEC state. Figure 1 (b) displays the isothermal fractional change in κ as a function of field. Clearly, the most pronounced changes occur as the temperature is lowered. In addition, κ does not appear to saturate even at the highest fields. Judging from these preliminary findings, it is of great interest to extend these measurements to even lower temperatures and higher magnetic fields.

This is the first such measurement to be performed at LANL and can be easily extended to the 20 T superconducting magnet system, the resistive/hybrid DC magnets in Tallahassee and down to ^{3}He temperatures (0.3 K). This method can be a powerful tool to investigate many other materials and phenomena and has been largely unexplored at high magnetic fields.

Acknowledgements

This work was supported by the NSF through the NHMFL, the State of Florida and the Department of Energy.

References

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