SEARCH FOR 2nd SOUND AT 50 mK in BEC COMPOUND $NiCl_2$-$4SC(NH_2)_2$

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Spin gap compounds can exhibit many interesting quantum effects that can 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). $NiCl_2$-$4SC(NH_2)_2$ is a prime candidate for this sort of effect [1]. The detection of "second sound" in this compound may lead to a more direct confirmation of this hypothesis, as second sound is a hallmark of superfluid ^{4}He, probably the most dramatic realization of a BEC in a condensed system. The supposed BEC state in $NiCl_2$-$4SC(NH_2)_2$ occurs below 1 K in fields from 2-12 T, therefore, we have used the dilution refrigerator in the 20 T superconducting magnet available at NHMFL-LANL.

A pulse-echo technique was utilized in order to detect second sound. The second sound detector and generators were composed of Carbon paint applied directly to either end of a cut parallelepiped sample. A pulse generator was used to heat the carbon film at one end of the sample, while the temperature of the opposite end was monitored with the second carbon film. If second sound exists in the sample, a "temperature wave" should be evident at the detector. The speed of second sound can be directly ascertained my measuring the time-of-flight. The connection between second sound and the proposed BEC state of this compound can be determined by measuring second sound with and without field. No calibration is needed since this measurement requires only the determination of the time-of-flight. An example signal, taken at 0 T and 50 mK are shown in Fig. 1. The rise in the signal near to where the heater pulse was initiated is probably due to cross-talk within the wires. At larger heater powers, the second sound detector showed the sample heating up and then cooling off again on a much longer time scale. In any case, no second sound is expected here at zero fields, so that this plot should be taken as a "background" signal.

No second sound signal was detected down to 50 mK and up to 12 T. The second sound plot did not change from that in Fig. 1, although different heater powers were applied to the second sound generator. It remains to be seen whether the signal to noise ratio is inadequate, or that the proposed effect may not be present.

Acknowledgements

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

References

[1] V. Zapf *et al.* Phys. Rev. Lett. **96**, 077204 (2006).

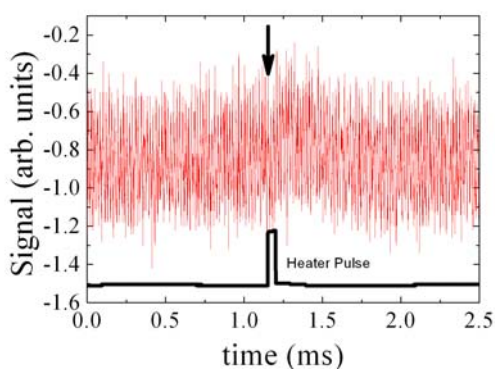

Fig 1. *Second sound experiment in magnon BEC compound $NiCl_2$-$4SC(NH_2)_2$ at zero field and 50 mK. The red curve is the signal from the second sound detector, whilst the black curve denotes the heater pulse.*