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Heat capacity of the crystal field effects in the $ErNi_2B_2C$ Compound

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ABSTRACT

Specific heat data on the new quaternary magnetic superconductor $ErNi_2B_2C$ is presented in the temperature range 20-300K. Crystalline Electric Feild Effects (CEF) are confirmed by the existence of a Schottky anomaly around 45K with a magnitude of 10 $Jmol^{-1}K^{-1}$. The Schottky peak is analysed in terms of a CEF levels scheme based on neutron data.

1. INTRODUCTION

Anomalous properties due to the coexistence of magnetism and superconductivity have been investigated with great interest in the ternary magnetic superconducting RE-Mo_6O_8 and RE-Rh_4B_4 (RE:Rare-Earth) series(1, 2). The interplay between magnetism and superconductivity could not be clarified until the nature of the different interactions involved in these materials was well understood. It was found that in addition to the long range magnetic order, CEF effects were of paramount importance, particularly in shaping the magnetic properties. The CEF specific heat (Schottky anomaly), being the thermal average over the CEF excitations, provides an important check on any proposed CEF levels scheme. The newly discovered quaternary superconductors series RE-Ni_2B_2C(3) seem to exhibit the same kind of phenomena when the RE carries a moment. We attempt to determine the CEF parameters in the $ErNi_2B_2C$ system from specific heat (C_p) and neutron data.

2. EXPERIMENTAL

A polycrystalline $ErNi_2B_2C$ sample was prepared, using a standard arc-melting technique, from high purity metals Er(99.9%), Ni(99.99%), B(99.9%) and graphite flakes. These constituents were melted several times in an argon atmosphere to ensure homogeneity, before annealing at 1000 °C for 14 hours. X-ray analysis indicated the sample is a single phase material. Resistivity and magnetic susceptibility data showed a transition temperature of 9K and a transition width of 1K . Specific heat data were collected from an adiabatic sweep calorimeter between 20 and 300K on a 100mg sample of $ErNi_2B_2C$. A YNi_2B_2C sample was also studied and used as a reference for the phonon contribution. The neutron inelastic scattering experiments with energy transfers up to 40meV were carried out on the HET and MARI spectrometers at the Rutherford Appleton Laboratory.

3. RESULTS AND DISCUSSION

The inverse magnetic susceptibility is mainly linear with temperature and presents no feature above the superconducting transition (fig.1). This despite the strong anisotropic effects of CEF on the magnetic properties observed in single crystal work on the RE-Rh_4B_4 series. The reason lies in the fact that in polycrystalline samples it can average out to a simple Curie-Wiess law, as already seen in the above mentioned systems (4).

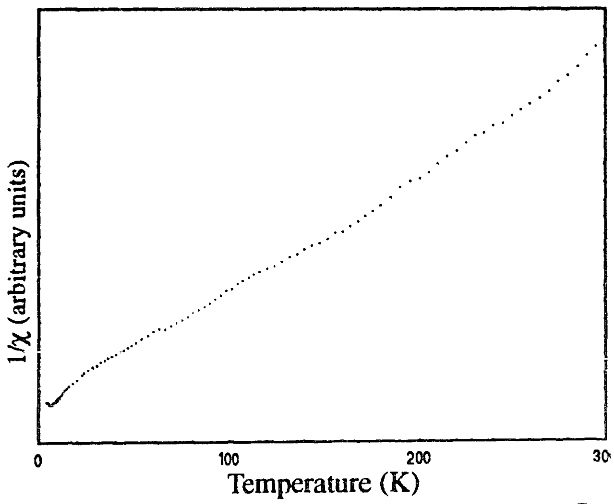

Fig.1 Inverse magnetic susceptibility of $ErNi_2B_2C$ versus temperature.

Since the Rare-Earth ion Y is non magnetic, we used a sample of the isostructural YNi_2B_2C to subtract the

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phonon contribution to the $ErNi_2B_2C$ specific heat. Fig.2 is the net magnetic contribution which peaks at 45K with a maximum value of 10J/mol K, the same order of magnitude as RE-Rh_4B_4[1].

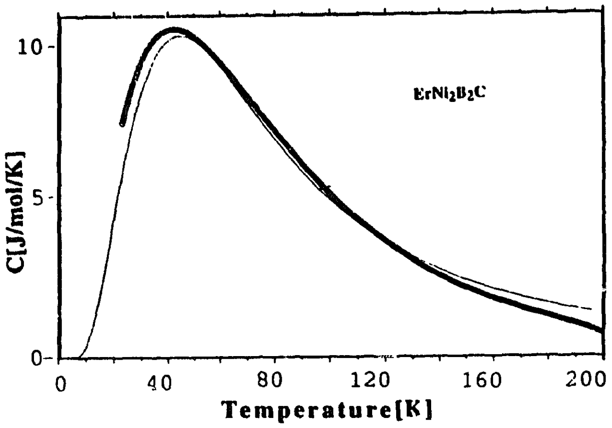

Fig.2 Specific heat of $ErNi_2B_2C$ after subtraction of the phonon contribution. Experimental data (oo) and predicted specific heat (solid line) from the CEF parameters in fig.3c

The CEF parameters inferred from the best fit to the inelastic neutron scattering data (fig.3a) is shown in fig. 3b whereas, a best fit to the specific heat results (fig.2) based on the same data so far suggests a set of levels similar to those shown in fig.3c. However, while this latter scheme reproduces the Schottky anomaly in magnitude and position, it should be noted that it sets a severe compromise as it skips completely the evident feature around 16meV in the neutron data. Further improvement may be brought about by investigating (with higher resolution at low energy transfer) potential low lying CEF levels on one hand, and the use of a better reference sample for the subtraction of the phonon background in the C_p data. A better candidate is the $LuNi_2B_2C$. Lu being of very comparable mass to Er but heavier than Y, the subtraction of the phonon background should result in a shift of the peak to lower temperatures, a direction favoured by the neutron data.

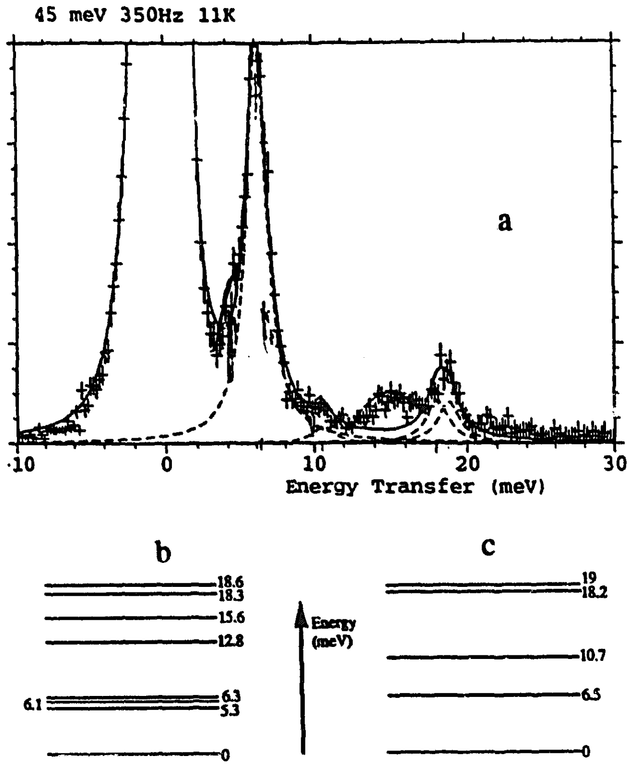

Fig.3 a: Inelastic neutron scattering data, (+) experi tal results,(solid line) fit to the neutron data using the CEF parameters in fig.3c.
b: Energy level diagram from the CEF best fit parameters.
c: Compromise CEF levels scheme between neutron and specific heat data.

4. CONCLUSION

Specific heat and neutron data reveal the the presence and the importance of the CEF effects in the $ErNi_2B_2C$ superconducting compound. As a first attempt , a compromise on the CEF parameters helped to reproduce quantitatively the Schottky anomaly in position ar magnitude. Further experiments are suggested to relax this compromise, and work is in progress to investigate the CEF effects in the $HoNi_2B_2C$ system.

5. REFERENCES

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