Refinement of the crystal field interaction for the rare earth intermetallic series $RNiAl_4$ (R = rare earth)

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The intermetallic series $RNiAl_4$ (R = rare earth) exhibits interesting magnetic behaviour[1-2] including the potential for low temperature, inverse, magnetic cooling[3]. Given that the $RNiAl_4$ magnetism is associated solely with the R sub-lattice and is influenced strongly by the local crystal field (CF) interaction at the R-site, it is important that the CF interaction be characterised.

Thermal neutrons have therefore been employed in an effort to extend a previous cold neutron inelastic neutron scattering (INS) investigation[4] to higher energy CF transitions at the single Er^{3+} site in $ErNiAl_4$. Measurements were performed using both the elastic and inelastic modes of operation of the C5 polarised triple-axis spectrometer at CNBC. The INS spectra were accumulated with a final scattering energy of E_f = 14 meV. Results from the report number CNBC-2014-QM-1 have now been published[5] and this second report describes further spin-polarised, neutron scattering data.

New elastic neutron scattering data were recorded to monitor the magnetic intensity component of the reflection at Q = 2.3134 $Å^{-1}$ (2θ = 51.75°) as a function of temperature (Fig. 1) The spin flip SF(HF-VF) and non spin flip NSF(VF-HF) data are in close agreement and, again, consistent with a Néel temperature in the range of 6.5 - 7.5 K. Based on the suggestion of a further magnetic transition below 3 K, it may be useful to extend specific heat measurements[6] to this lower temperature region.

In the previous report, the stripping of normalised INS spectra for $YNiAl_4$ from the INS spectra for $ErNiAl_4$ led to speculation that there were additional, low intensity CF transitions at ≈14.4 and ≈18.2 meV. However, this is not supported by the new INS spectra recorded using spin-polarised neutrons. The spin flip SF(HF-VF) and non spin flip NSF(VF-HF) spectra shown in Fig. 2 for T = 10 K and Q = 3 $Å^{-1}$ provide typical examples. The strong CF transitions at 3.1 and 7.5 meV remain. However, all other features (including what appears to be an instrumental artefact at 25 meV) are removed by the subtraction process and the resultant spectra are flat across the energy range of 15 – 50 meV. Despite the relatively large intensity scatter, these new data also cast doubt on the CF nature of the weaker 11.6 meV peak observed previously using unpolarised INS both at BENSC[4] and at CNBC[5].

We now plan to look for further CF transitions at lower energies using a high resolution, time-of-flight instrument.

References

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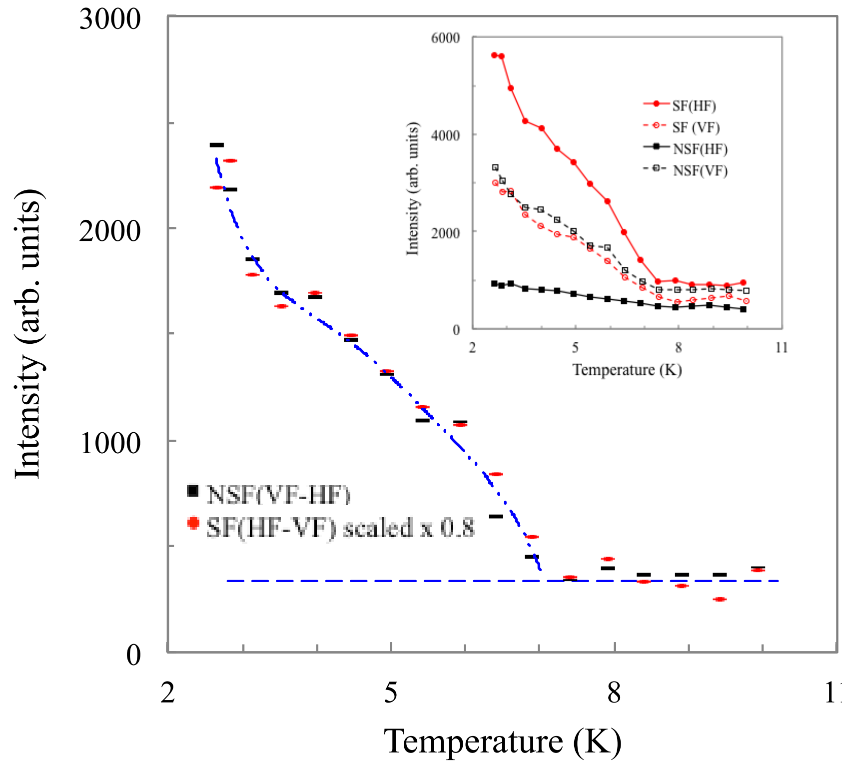

Figure 1 Temperature dependence of the spin flip SF(HF-VF) and non spin flip NSF(VF-HF) magnetic intensities for the $ErNiAl_4$, 2θ = 51.75°, elastic reflection.

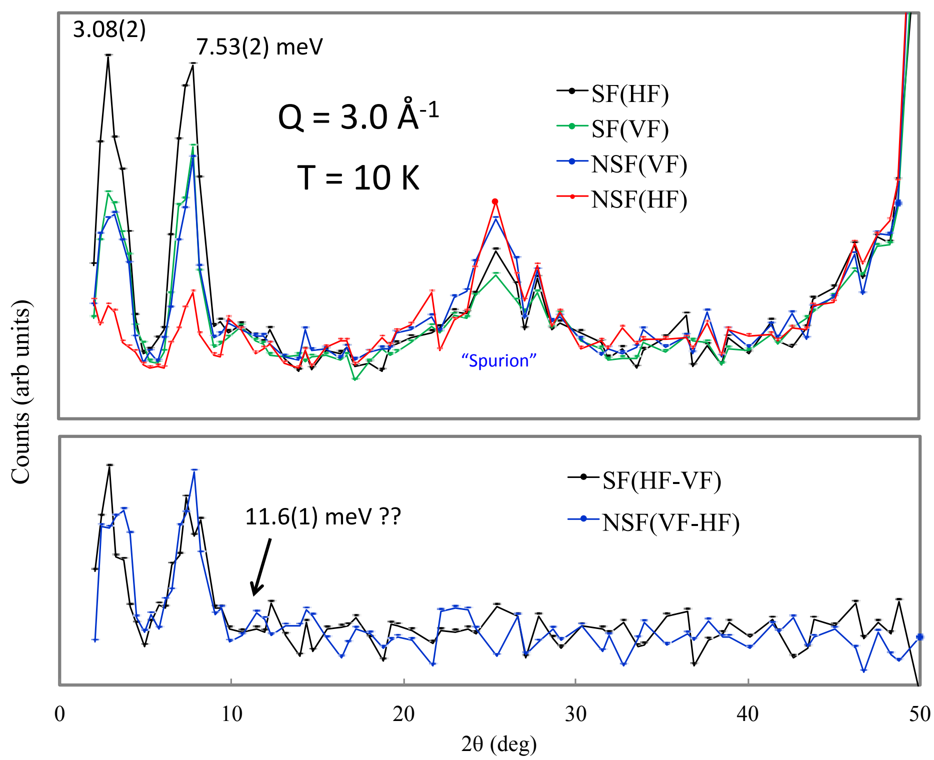

Figure 2 Spin flip SF(HF-VF) and non spin flip NSF(VF-HF) INS spectra for $ErNiAl_4$ at T = 10 K and Q = 3 $Å^{-1}$.