ESRF	Experiment title: Resonant x-ray magnetic scattering on $(U_{1-x}Np_x)Ru_2Si_2$	Experiment number: HE 195
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Report:

This experiment was a continuation of an examination of the $Np_{1-x}U_xRu_2Si_2$ series of compounds. A 10% neptunium compound was examined in the experiment reported here, The pure uranium compound is a well-known heavy fermion that has an ordered magnetic moment of only $0.02\mu_B$. The nature of its ground state is not well understood so it is of interest to study the effects of mixing with neptunium, which constitutes a fairly small perturbation to the system. From Mössbauer studies it is known that the neptunium moment is constant at at about 1.6 μ_B down to 10% Np concentration.

Due to the element specificity of resonant magnetic scattering, it is possible to study the magnetism of neptunium and uranium separately. We performed two kinds of experiments: scanning the energy to study the resonant enhancement as a function of energy, and measuring the intensity as a function of temperature. The magnetic structure was found to be the same as that of the pure uranium compound, that is, a simple antiferromagnet with propagation vector [0 0 1] and the moments along the c-axis. Fig. 1 shows the intensity corrected for absorption as function of energy for the (0 0 5) reflection at 10 K. Assuming that the resonant enhancements for neptunium and uranium are approximately equal, we find a moment of the order of 0.5 μ_B on the uranium. Thus, a substitution of 10% of neptunium neptunium drastically changes the magnetic state of the uranium.

From the energy scan data we can also deduce the branching ratio of neptunium, that is, the ratio $(\text{Intensity(M4)}/\text{Intensity(M5)})^{1/2}$. Unfortunately, it is difficult to simply compare this ratio with that of another compound since it is strongly dependent on the crystal field parameters amongs other things. The second part of our experiment was to measure the magnetic intensity for the two magnetic species separately. This was done in two ways, obtaining the integrated intesities through rocking theta, and sitting at a magnetic peak and scanning the temperature whilst recording the intensity. The sample quality was not as good as in our previous experiment and we identified a number of grains. It was therefore found that the first method was unreliable. A large number of peaks were investigated with the second method at the uranium and neptunium M4 edges. One grain was also investigated at the neptunium MS edge. The data were all treated the same way: the high temperature background was subtracted and the data were then normalised at 10 K. The data was then binned to reduce the scatter. The result is displayed in Fig. 2.

From Fig. 2 it is clear that the temperature dependence of the magnetisation is different for the two species. It appears that the uranium moment is "pulled up" by the neptunium. It is worth emphasising that no un-binned data or theta rock data for the uranium edge overlapped with any neptunium data in the intermediate temperature region. A similar situation, i.e. $\beta_{Np}<\beta_U$ was also found in the 50% Np doped material.

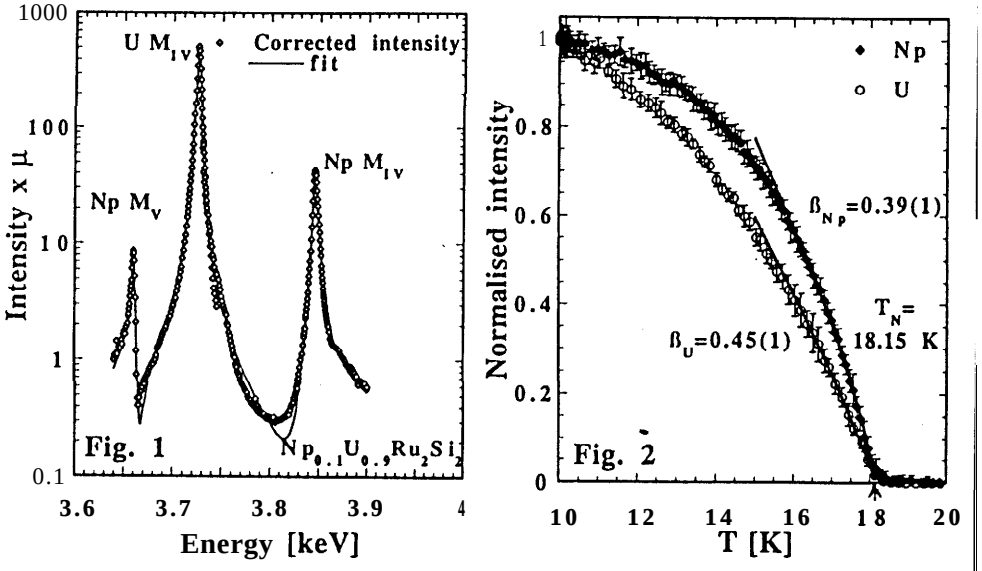

Fig. 1. Energy scans of the magnetic intensity for the (0 0 5) peak. The data have been corrected for absorption by air, Kapton and beryllium, as well as for the self-absorption of the sample. The solid line is a fit to three harmonic oscillators.

Fig. 2. The normalised magnetic intensity of the (0 0 5) peak at the uranium and neptunium M4 edges as well as at the neptunium M5 edge.