



Experiment title: Search for quadrupolar or magnetic order in Pt-doped UPd₃

Experiment number:
He-2771

Beamline:
ID20

Date of experiment:
from: 16/07/2008 to: 22/07/2008

Date of report:
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Shifts:
18

Local contact(s):
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Report:

UPd₃ is one of the few compounds which has been shown to exhibit long range quadrupolar order, and it is even more fascinating in that it has four transitions at low temperatures to a variety of phases each with different quadrupole moments being ordered. The order parameters in these phases were elucidated in previous experiments on ID20 [1,2]. The number, and varied nature, of the low temperature phases show that there is a fine competition between the different quadrupolar exchange interactions involved. However, on doping with even a small amount of platinum, some of these interactions may be suppressed allowing us to examine a simpler system. In the present case, U(Pt_{0.005}Pd_{0.995})₃, heat capacity measurements show only a single transition at ~4.5K, and the goal of this experiment is to determine the quadrupolar order in the phase below this transition.

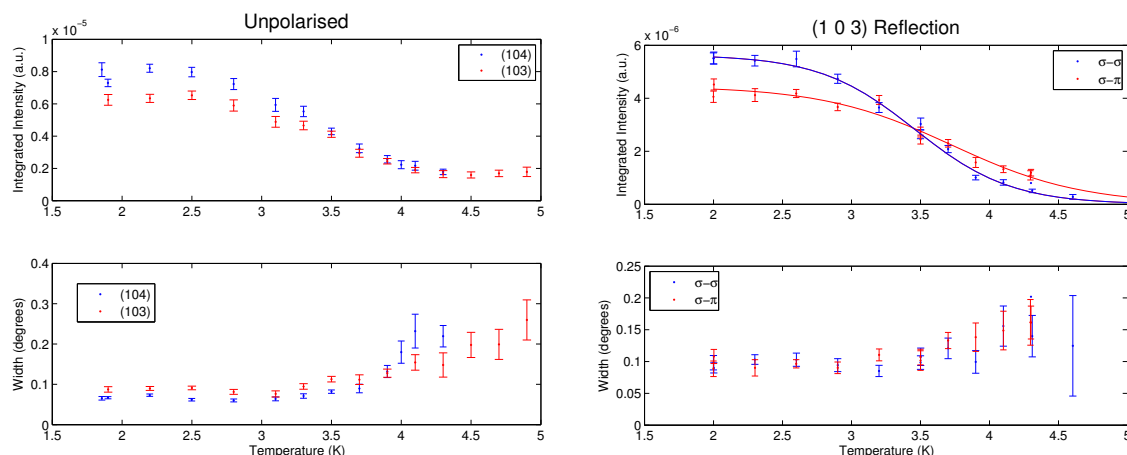


Figure 1. Temperature dependence of the unpolarised (103) and (104) reflections (left), and that of the (103) reflection in the σ - σ and σ - π channels with polarisation analysis (right). The lines on the right panel are guides to the eye.

We used a polished single crystal cut with a face perpendicular to the [207] direction so that the angle to the superlattice reflections at (103) and (104) arising from the antiferro- and ferro-quadrupolar ordering respectively would be small allowing a large range of azimuth to be scanned.

Figure 1 shows the temperature dependence of the unpolarised integrated intensity of the two reflections on the left, and that for the two scattered polarisation channels for the (103) reflection on the right. Also shown at the bottom is the half width at half maximum (HWHM) of the peaks in theta rocking scans. The observed behaviour is consistent with a single phase transition, but the polarised data shows a crossing over of the σ - σ and σ - π intensities near the transition. In addition, we observed a very narrow peak in the (103) reflection in the σ - σ reflection that persists above the transition temperature, and the energy dependence of this channel at 4.6K also shows a large background and an ill-defined resonant peak. The observation of scattering in σ - σ for both reflections strongly supports that the peaks originate from quadrupolar as opposed to magnetic ordering. Figure 2 shows the azimuthal dependence of integrated intensities for both polarisation channels at both reflections. The behaviour of the (104) reflection is nicely fitted by a single order parameter, Q_{xy} , which shows that in the low temperature phase, the order is described by a parallel stacking of Q_{xy} quadrupole moments along the c-axis. This is consistent with the behaviour observed in the lowest temperature phase of UPd₃ [2].

The azimuthal behaviour of the (103) reflection is more complicated and the best fit with the least number of order parameters requires the superposition of Q_{xy} , $Q_{x^2-y^2}^2$, and Q_{zz} . In addition an imaginary component of the Q_{xy} moment was required in order to fit the low peak around 270° in the σ - π channel. This may represent an ordering of the quadrupoles on the uranium hexagonal sites, or possibly be associated with the development of a dipole moment in addition to the quadrupole moment.

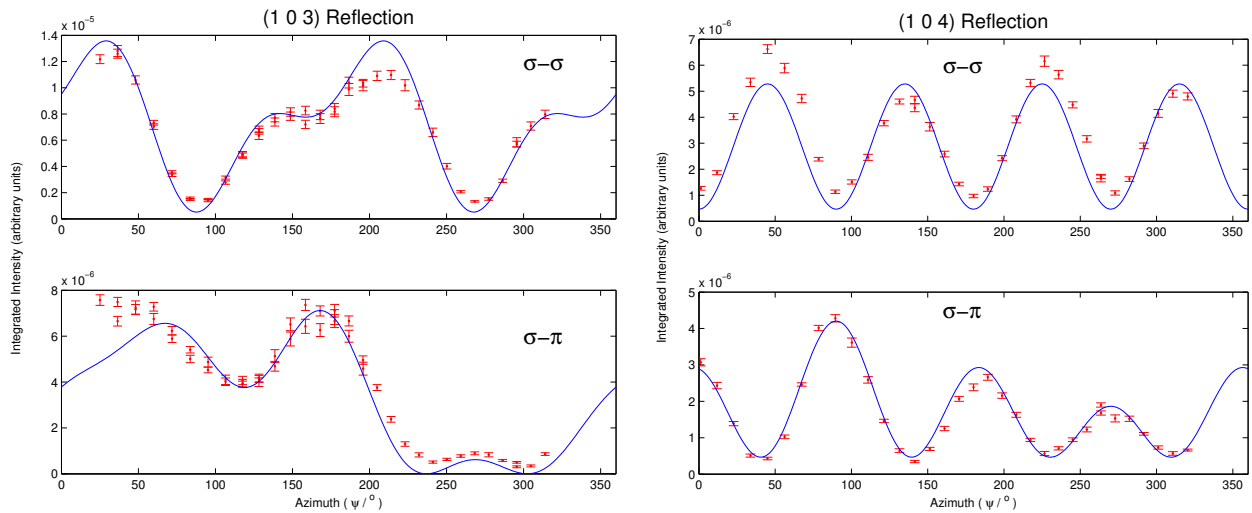


Figure 2. The azimuthal dependence of the (103), left, and (104), right, reflections. The blue lines are fits taking into account only Q_{xy} quadrupoles in the case of the (104) reflections, and Q_{xy} , $Q_{x^2-y^2}^2$, and Q_{zz} quadrupoles in that of (103).

References

- [1] H.C. Walker, K.A. McEwen, D.F. McMorrow, S.B. Willkins, F. Wastin, E. Colineau and D. Fort, *Phys. Rev. Lett.* **97** (2006) 137203
- [2] H.C. Walker, K.A. McEwen, M.D. Le, L. Paolasini and D. Fort, *J. Phys.: Condens. Matter* **20** (2008) 395221