Standard Experimental Report

Proposal title: Hidden order of URu2Si2: nature and impact of parasitic phases
Proposal number: 20210458
Beamline: D2AM
Shifts: 12
Date(s) of experiment: from: 23/09/2021 to: 27/09/2021
Date of report: 23/10/2021

- Objective & expected results (less than 10 lines): **-**

The objective was to characterise the parasitic phase observed in a previous experiment in URu_2Si_2. We wanted to investigate its structure (with reciprocal space maps, since we previously knew only 1 lattice parameter) and its spatial homogeneity in the sample, to check if it could be related to the heterogeneous parasitic dipolar magnetic order.

- Results and the conclusions of the study (main part): **-**

The known crystal structure of URu_2Si_2 has space group I4/mmm. In a previous experiment, we found additional weak reflections along the 00L axis, at positions L=(2n)(1-0.004): our hypothesis was a minority phase growing coherently with the main phase, and with a c lattice parameter 0.4% larger than the one of the main phase.
During this beamtime, we explored the reciprocal space to further understand the crystal structure of this minority phase. We measured the same sample as previously, plus another one from the same batch. Both samples yielded identical results. The additional peaks on 00L scans were found as previously.

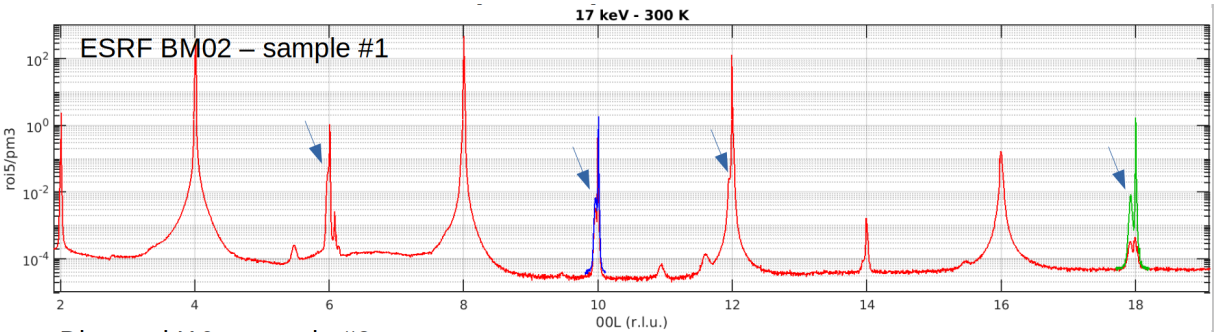

Figure 1: 00L scan (different colours indicate different measurements)

(H,K) maps were performed at the L values of the additional peaks, and we found the patterns below (Figure 2), for L=(2n)(1-0.004) (left) and L=(2n+1)(1-0.004) (right).

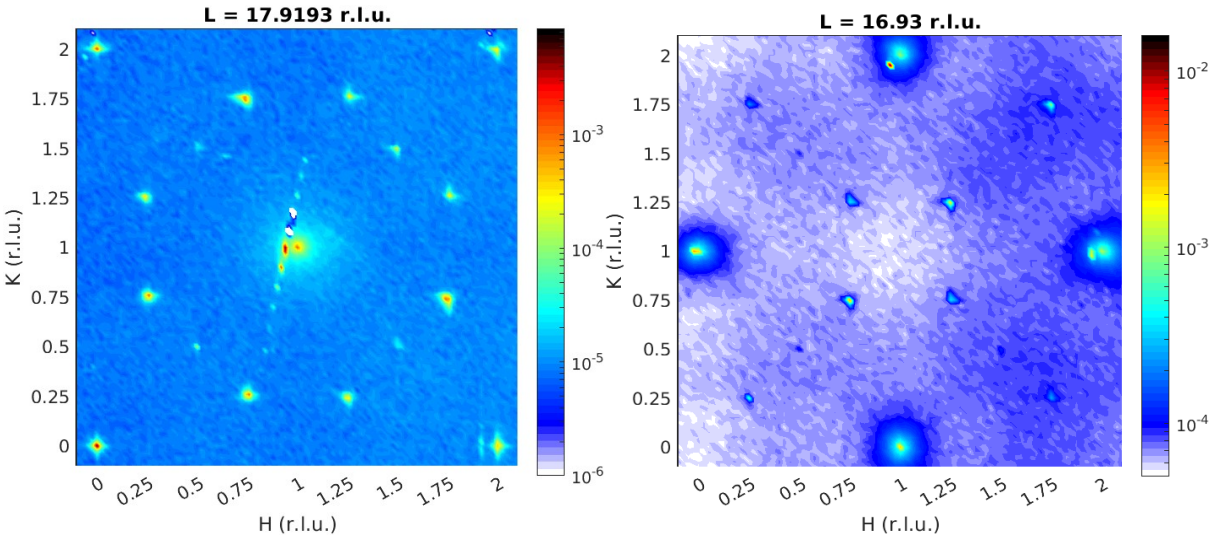

Figure 2: (H,K) maps at L=(2n)(1-0.004) (left) and L=(2n+1)(1-0.004) (right).

In both types of layers, peaks at integer H and K positions respect the body-centring rule H+K+L=2n. Additional peaks are found at half-integer H and K and at positions (H=¼, K=¾) and (H=¾, K=¼) for L=(2n)(1-0.004) layers, and at (H=¼, K=¼) and (H=¾, K=¾) for L=(2n+1)(1-0.004) layers (Figure 2).
We also found 2 new series a peaks, following the same (H, K) pattern,again at slightly different L values.

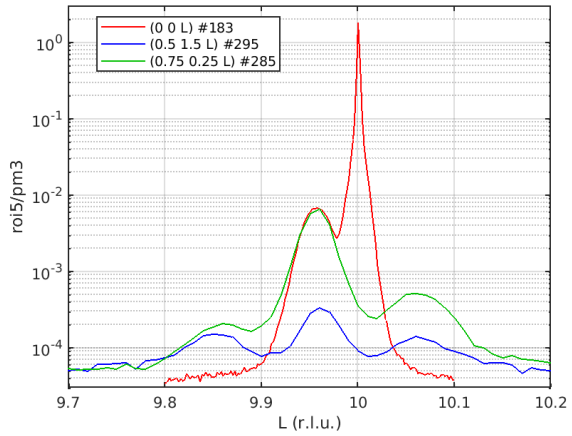

Figure 3: L scans around L=10 at different (H,K) values. Additional layers of peaks are found at L=9.85 and L=10.06.

At large L (for instance L~18) these new peaks appear to be split, suggesting domains with unit cells that are not strictly tetragonal (Figure 4).

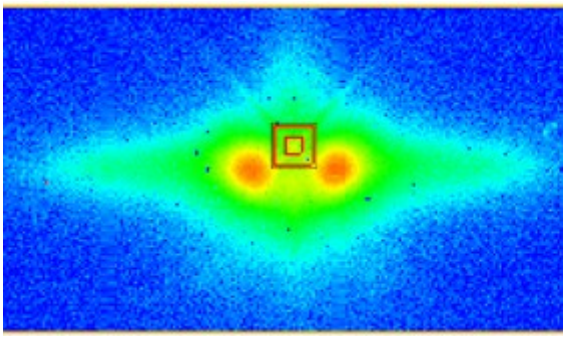

Figure 4: Detector image at position (2 0 17.805). The horizontal axis is nearly parallel to the K axis.

Measurements were performed first at room temperature, then at low temperature in a range from 6 K to 27 K (hence passing the hidden order transition). No change could be noticed, except for the diffuse scattering.

With a small beam (~40x40 µm²), we mapped the surface of one sample on several of reflections, and found it quite homogeneous, while the dipolar magnetic order at low temperature measured on the same sample had been found very heterogeneous.

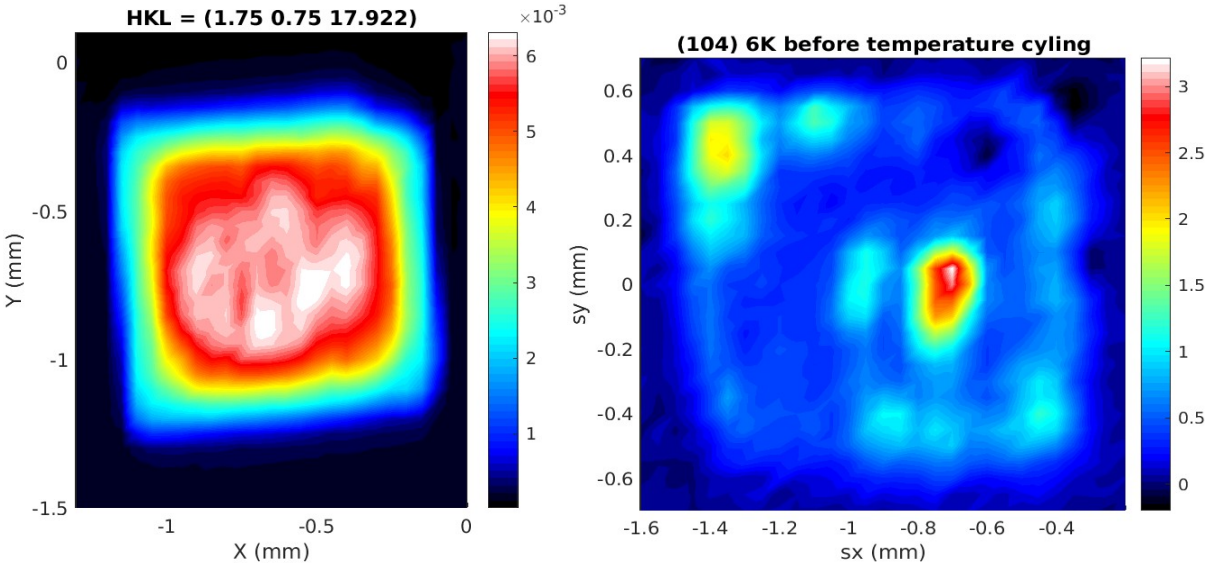

Figure 5: Map of the surface of the sample on a new reflection (left) and on a dipolar magnetic order reflection (right).

These results suggest that the secondary phase has nothing to do with the hidden order, nor with the dipolar magnetic order.

- Justification and comments about the use of beam time (5 lines max.): -
The beamtime was used exactly as planned in the proposal.

- Publication(s): -
In preparation