Reply to commented review from Kuznietz



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**REPLY**

# Reply to commented review from Kuznietz

**Z Fisk, N O Moreno, J D Thompson and M F Hundley**

K764, Los Alamos National Laboratory, Los Alamos, NM 87545, USA

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The suggestion of Kuznietz is simply stated: a ferromagnetic domain structure can explain what we have interpreted as a first order low temperature transition to an antiferromagnetic state from a higher temperature ferromagnetic one in Cu-flux-grown single crystals of $UCu_2Si_2$. Part of his argument is based on a number of neutron diffraction studies of the ferromagnetic order found below 100 K in polycrystalline material. Our contention is that Cu-flux-grown crystals are not identical to the polycrystals previously studied, showing a 50 K first order transition in addition to the 100 K ferromagnetic one seen in polycrystals. Part of the motivation for this study came, in fact, from the long known dependence on stoichiometry of highly correlated electron materials in the $ThCr_2Si_2$ structure, in particular the superconductivity in $CeCu_2Si_2$ depending on excess Cu in the material.

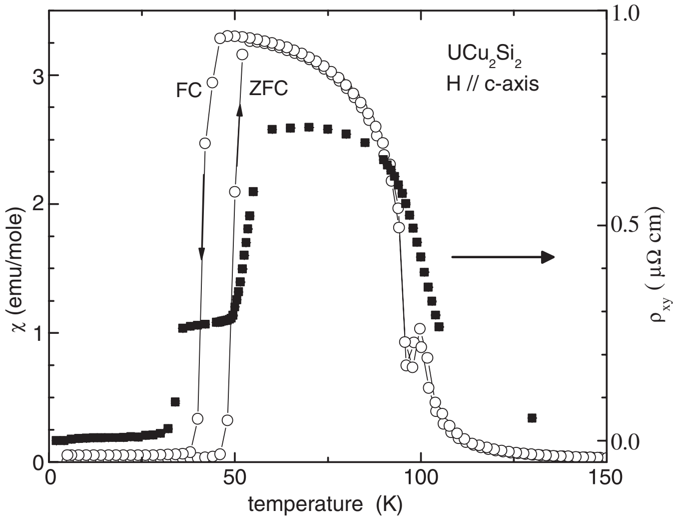


**Figure 1.** Plot of Hall resistivity rhoxy of $UCu_2Si_2$ measured in 10 kOe field applied parallel to the c-axis versus temperature. Also shown are the zero field cooled and field cooled magnetic susceptibilities, both measured in 1 kOe field parallel to the c-axis.

Our reasons for believing that ferromagnetic domain structure does not explain what we observe are several. First, the transition at 50 K is reproducibly observed in all crystals grown by this method, both from the same batch and different batches, including crystals grown with small amounts of Gd additions for epr measurements. We suggest it is unexpected for the domain effects to be so precisely reproducible. Further, temperature cycling does not affect this transition. We see the sharp, first-order-like transition both on warming and cooling cycles in an applied magnetic field of 1 kOe. On cooling in this field, the transition is suppressed by 5 K, such hysteresis in a first order transition being not unexpected. We also note that the 5 K magnetization loop shows intermediate structure which corresponds to our claimed antiferromagnetic state. That magnetic domains would reproduce this on field cycling appears unlikely to us. The very sharp transition seen in this magnetization curve also speaks to the first order nature of the transition, rather than the flipping or growth of ferromagnetic domains. Finally, we mention we have extensive unpublished Hall effect data obtained from our crystals. A plot of the temperature-dependent Hall resistivity $\rho_{xy}$ measured in a 10 kOe field (see figure 1) shows the ferromagnetic transition at 100 K and two additional step-like features at 50 and 30 K. The field-dependent Hall data cleanly follow the changes in magnetization. The straightforward interpretation of these data in terms of ordinary and extraordinary components, combined with the observation below the 50 K transition of steps in the field corresponding to what is seen in the magnetization, are definitely not due to domain effects. Lastly we point out that the change in heat capacity at 50 K is consistent with a AFM–FM transition. Since both states are ordered, no prominent anomaly is expected at the AFM transition temperature. Instead, a transition from FM to AFM magnons should produce a change in the specific-heat temperature dependence, as observed.