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Report:

CeCu₂(Si_{0.5}Ge_{0.5})₂ orders antiferromagnetically below $T_N \approx 3$ K in an incommensurate magnetic structure with a wave vector $\tau \approx (0.28 0.28 0.52)$ as determined by neutron diffraction. The magnetic moments are assumed to be aligned along [110] and the value of the ordered magnetic moment is estimated to be $\approx 0.5 \mu_B$ at low temperatures. Additional phase transitions within the ordered state were observed at $T_1 \approx 2.2$ K, possibly a reorientation of the magnetic moments, and at $T_2 \approx 1.3$ K which is most likely a lock-in transition into a commensurate structure.

A thin piece of 0.5 mm thickness was cut from the same single crystal already used in the neutron experiment. The diffractometer was used in the horizontal configuration with a LiF (220) polarization analyser. The incident beam was π -polarized. The sample was mounted in the [110]-[001] scattering plane, diffracting off a large [001] surface. Most of the measurements were performed at the Ce L_{II} edge with a photon energy of $E = 6.164$ keV.

A 3 He closed cycle refrigerator allowed cooling the sample down to $T \approx 0.7$ K. However, strong beam heating effects were observed as soon as the sample was illuminated with x-rays: The measured temperature inside the copper sample holder increased to 0.85 K under full beam. In order to obtain an independent measurement of the integrated sample temperature, we performed simultaneous in-situ resistivity measurements using a 4-probe technique. The beam heating effects were anticipated, and the experiment was performed in 16-bunch mode to reduce local heating of the sample in the beam spot. However, this aim was not achieved, even when the incident beam was further attenuated. Furthermore, the period of only 6 hours between refills, and the large variation of beam current (nearly a factor of 2) turned out to be a significant problem. Therefore future experiments should be carried out in 200 mA multi-bunch mode, with better beam stability, longer life time and smaller variation of the incident intensity.

We estimated the heating of the sample in the illuminated region of the beam to be more than 1 K. Since this heating is local, the temperature determined by the resistance measurement of the whole sample, can only give a lower bound for the temperature in the scattering volume. The temperature in the scattering volume is assumed to be not constant, but showing the highest value in the center and decreasing towards the bounds of the scattering volume due to the thermal conductivity. Therefore we expected to observe scattering from regions of the scattering volume with different temperatures at the same time. This complicated to deduce unambiguous results for the temperature dependence of charge and magnetic reflections.

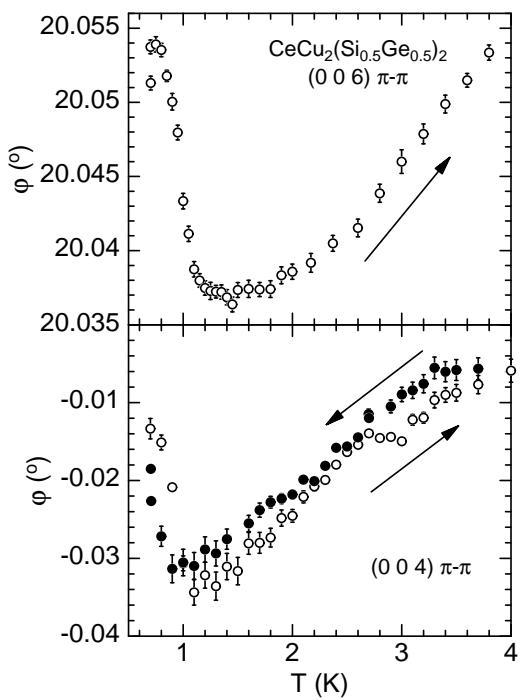


Fig.1. Temperature dependence of the peak position of the (004) and (006) charge peaks measured in $\pi - \pi$ polarization as determined by rocking scans.

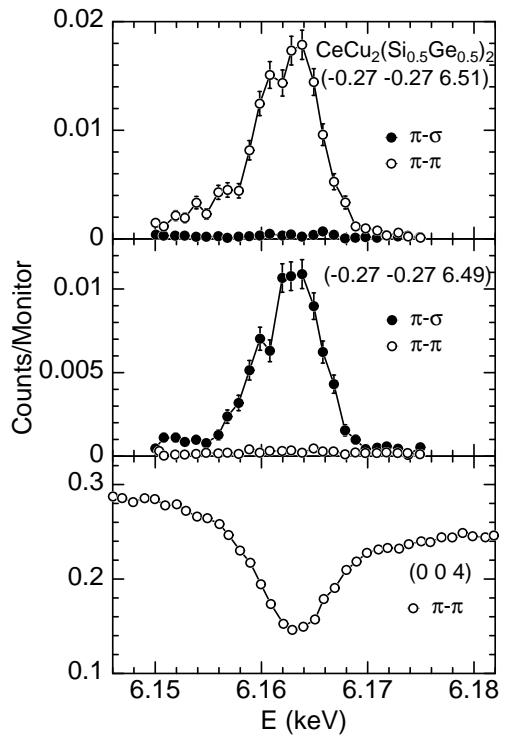


Fig.2. Energy scans at the positions of the magnetic satellite reflections $(-0.27 - 0.27 6.49)$ and $(-0.27 - 0.27 6.51)$ in $\pi - \pi$ and $\pi - \sigma$ polarization as well as the (004) charge peak in $\pi - \pi$ polarization at nominal lowest temperature $T \approx 0.85$ K.

First we want to focus on the charge peaks. Fig. 1 displays the peak positions of the (004) and (006) charge peaks as a function of temperature. The peak positions show a strong temperature dependence and more important a sharp anomaly (sudden drop) above $T \approx 1$ K. This effect is seen during both heating and cooling, and is orders of magnitude larger than expected from thermo-elastic effects measured by thermal expansion. The origin of this 1 K effect might be a movement of the ³He-cryostat, but also a ⁴He leak in the cryostat could have some effect at ≈ 1 K when the vapor pressure of ⁴He starts to become significant. Magnetic reflections were observed at nominal base temperature ($T \approx 0.85$ K) in resonance condition at the Ce-L_{II}-edge. Fig. 2 displays energy scans across two magnetic peaks and the (004) charge peak for different polarization of incident and diffracted beam. The dip in the intensity of the (004) peak at $E \approx 6.163$ keV clearly shows the signature of the Ce-L_{II} absorption edge. Magnetic satellite peaks are found in $\pi - \pi$ and $\pi - \sigma$ polarization but at slightly different positions in q space. The propagation vectors are determined to be $\tau_1 \approx (0.27 0.27 0.51)$ for $\pi - \pi$ polarization and $\tau_2 \approx (0.27 0.27 0.49)$ for $\pi - \sigma$ polarization. This is surprising since in neutron diffraction only one propagation vector was found which agrees with τ_1 . However, the neutron experiment did not allow to determine the c^* component of the propagation vector very accurately due to a relaxed vertical resolution. Related neighboring magnetic peaks with different polarization have comparable intensity and the magnetic peaks belonging to τ_1 and τ_2 vanish at $T \approx 1.2$ K. At this temperature one would normally not expect any transition in this compound. However, beam heating or the effect already seen in the charge peaks at ≈ 1 K could be the origin for the disappearance of the magnetic intensity at ≈ 1.2 K. In addition, although both magnetic structures vanish at the same temperature, the magnetic intensities originate probably from different regions in the scattering volume being at different temperatures. The $\pi \rightarrow \pi$ resonant cross section is sensitive to magnetic moments perpendicular to the scattering plane, i.e. parallel [1̄10] (τ_1 reflection), whereas the $\pi \rightarrow \sigma$ cross section is sensitive to moments within the scattering plane, i.e. along [11ξ] (τ_2 reflection). Neutron diffraction and thermodynamic measurements observe a spin reorientation transition close to $T_1 \approx 2.2$ K. This indicates inhomogenous beam heating effects of at least 1 K in the center of the beam spot, and contributions of both the high- and low- T magnetic structures to the observed signal. No magnetic resonance signal was found at the Ce-L_{III}-edge.