Magnetic Modulation and Large Magnetoresistance in Cr_5Te_8

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Because of the ability to manipulate their structure and properties, metallic 2D van der Waals materials that exhibit ferromagnetism (FM) are of considerable potential interest for spintronics applications. Cr_5Te_8 is such a system whose structure consists of layers of $CrTe_2$ having additional Cr intercalated between the layers. $CrTe_2$ itself is known to be a strong ferromagnet up to room temperature [1]. Cr_5Te_8 is FM below T_{c1}=155K with perpendicular magnetic anisotropy and it exhibits a large (10%) negative magneto-resistance effect above T_{c1} over a narrow temperature range [2].

We have performed neutron diffraction measurements to explore the magnetic behavior in a temperature range above T_{c1} and as a function of applied magnetic field. A modulated antiferromagnetic phase is observed, which has a wavevector perpendicular to the van der Waals layers and a period that is triple the unit cell length. The modulated spin structure is canted with a significant component in the van der Waals layers. The modulation is robust with field applied in-plane but it is quickly destroyed with a field applied perpendicular to the layers. Our magnetic phase diagram shows that the transition from FM to the modulated phase at T_{c1} is strongly first-order with a true FM transition occurring at a higher temperature, T_c=180K. We show that the large magnetoresistance observed in transport arises from the in-plane components of the magnetic moments. Since the spin modulation is controlled at relatively low magnetic field and the intercalated Cr can be tuned, 2D systems such as these have potential for spintronic applications.

Support: NSF-DMR; the University of Missouri Research Reactor. Spallation Neutron Source at Oak Ridge National Lab is supported by the US Department of Energy.

[1] Room-temperature intrinsic ferromagnetism in epitaxial CrTe2 ultrathin films X. Zhang *et al.*, *Nature Communications* **12**:2492 (2021)
[2] Self-Intercalation Tunable Interlayer Exchange Coupling in a Synthetic Van der Waals Antiferromagnet X. Zhang *et al.*, *Advanced Functional Materials* 2202977 (2022)

Supplementary Pages (Optional)

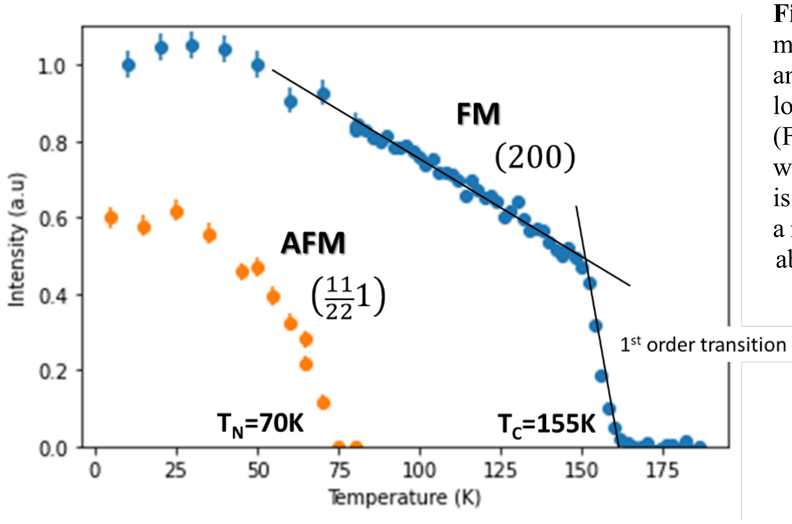


Fig. 1. Neutron Diffraction finds two magnetic phases in Cr_5Te_8, an antiferromagnetic (AFM) phase at low temperature and a ferromagnetic (FM) phase at higher temperature with T_{c1}=155K. The latter transition is strongly first order as it gives rise to a magnetically modulated AFM phase above T_{c1}.

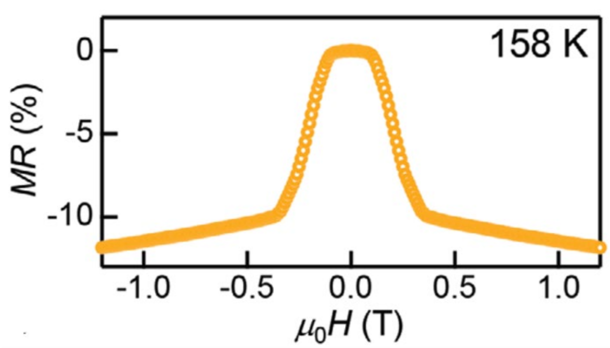
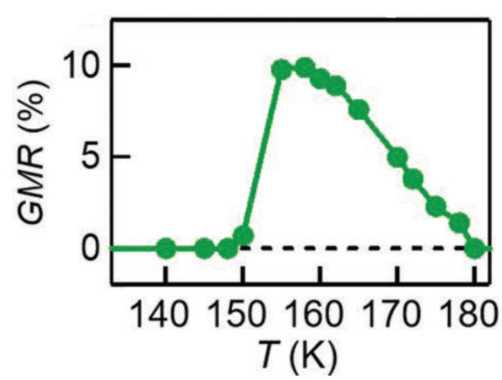


Fig. 2(a). A large negative magnetoresistance is observed in Cr_5Te_8. X. Q. Zhang et al., Adv. Funct. Mater. 2202977 (2022).

Fig. 2(b). The large magneto resistance exists above the FM transition temperature over a narrow (~30K) temperature range.



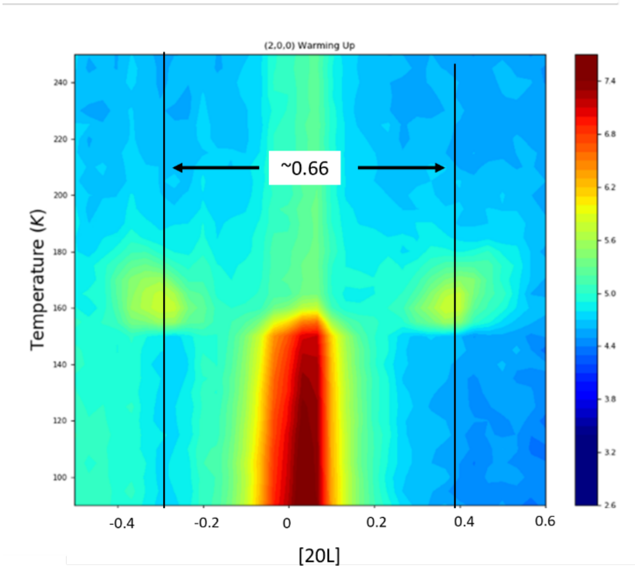


Fig. 3. Neutron diffraction results showing the onset of the modulated AFM phase above T_{c1}. The modulation has a period perpendicular to the van der Waals layers equal to three times the unit cell length.

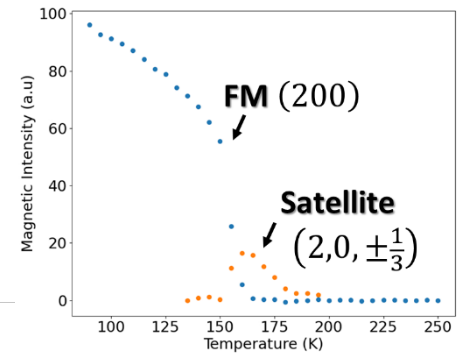


Fig. 4 Spin structure of the AFM modulated phase determined by neutron diffraction. Note the significant in-plane components of the magnetic moments, which strongly affect the spin-dependent electron scattering and hence the strong magnetoresistance effect.

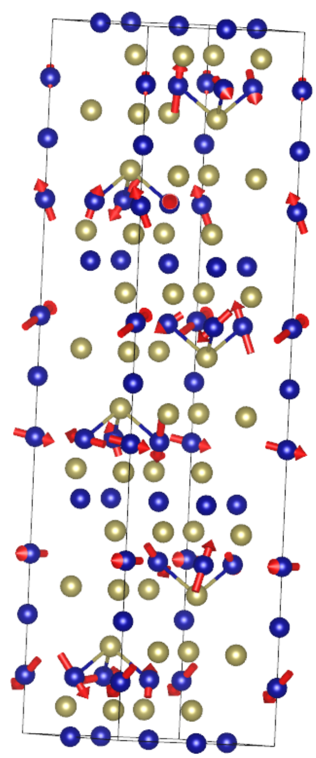


Fig. 5. The neutron intensity of the modulation peak is shown for two field orientations. The field perpendicular to the van der Waal layers sensitively destroys the modulation as the moments are forced back into the ferromagnetic phase whereas the modulation is robust to an in-plane field.