

Pulsed fields detect a dramatic change of electronic character in the ferromagnet Fe_{3-x}GeTe₂

S. Vaidya¹, M. J. Coak^{1,2}, D. A. Mayoh¹, M. R. Lees¹, G. Balakrishnan¹, J. Singleton³ and P. A. Goddard¹

¹Department of Physics, University of Warwick, ²School of Physics & Astronomy, University of Birmingham, ³National High Magnetic Field Laboratory - LANL



Funding Grants: K. M. Amm (NSF DMR-2128556); J. Singleton (NSF DMR-2128556; DOE Science of 100 T); Goddard/Balakrishnan (ERC 681260, EPSRC EP/T005963/1, EP/N032128/1)

Magnetic van der Waals materials provide an exciting testing ground for fundamental theories of magnetism in the extreme two-dimensional limit. Moreover, the ease with which they are exfoliated and reassembled has led to proposals for a wide range of novel magnetic devices. Within this family, Fe_{3-x}GeTe₂ (FGT) is very promising, as it has both a high Curie temperature and good electrical conductivity, leading to heterostructures with potential for low-power, room-temperature spintronic technologies. Interestingly, FGT also shows coexistence of itinerant and localized magnetism; as a result, it has been suggested that Kondo-lattice behavior develops at low temperatures. Whilst Kondo-lattice behavior is accepted in *f*-electron systems, its presence in *3d* compounds is controversial. An understanding of this issue is essential for designing future FGT devices.

In order to demonstrate Kondo-lattice behavior in FGT, magnetization [*M*(*H*) - Figure (a)] and resistivity [ρ_{xx} - Figure (b) and ρ_{xy}] data were recorded at many temperatures in pulsed magnetic fields of up to 60 T. These experiments reveal three distinct contributions to the magnetoresistance (MR; i.e., the variation of the resistivity in magnetic field): a linear negative component, a contribution from closed Fermi-surface orbits, and an enhancement proportional to the square of the applied magnetic field, linked to a noncoplanar spin arrangement. The availability of magnetization and resistivity data over a wide range of conditions enabled the ordinary Hall coefficient of FGT to be extracted reliably for the first time, demonstrating a significant change in character of the electrons and holes on the Fermi-surface at about 80 K; eventually, the Hall coefficient reverses sign at 35 K. This change in character supports the development of Kondo-lattice behavior in this *d*-electron material below 80 K. Additional evidence comes from the negative linear component of the MR, which arises from electron-magnon scattering with an atypical temperature dependence [inset in Figure (b)] attributable to the onset of Kondo screening.

Facilities and instrumentation used: PFF - 65 T magnet, magnetometer and 3D printed rotator

Citation: Vaidya, S.; Coak, M.J.; Mayoh, D.A.; Lees, M.R.; Balakrishnan, G.; Singleton, J.; Goddard, P.A., *Direct evidence from high-field magnetotransport for a dramatic change of quasiparticle character in van der Waals ferromagnet Fe_{3-x}GeTe₂*, Physical Review Research, **6**, L032008 (2024) doi.org/10.1103/PhysRevResearch.6.L032008

