Unconventional insulator-to-metal phase transition in $Mn_3Si_2Te_6$

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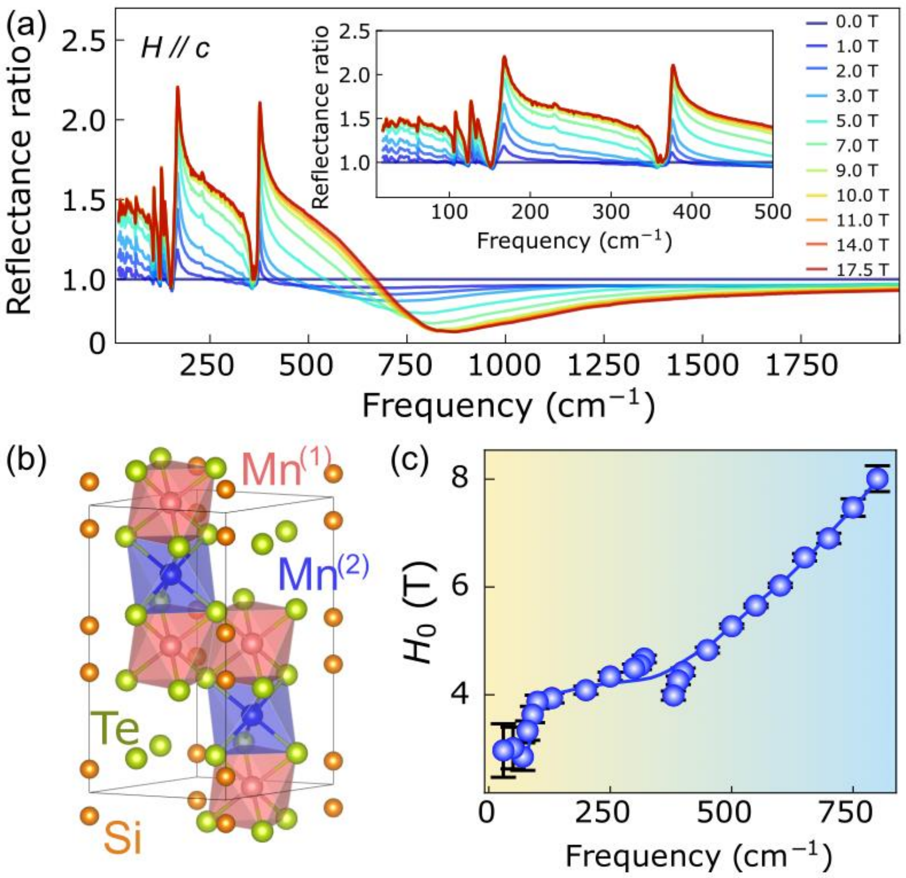
The nodal-line semiconductor $Mn_3Si_2Te_6$ is generating excitement in the materials science/condensed matter physics communities due to the recent discovery of a field-driven insulator-to-metal transition with accompanying colossal magnetoresistance as well as *evidence for a new type of quantum state involving chiral orbital currents.* Strikingly, these qualities persist even in the absence of traditional Jahn-Teller distortions and double-exchange mechanisms, raising questions about exactly how and why magnetoresistance occurs along with conjecture as to the likely signatures of loop currents.

In this work, MagLab users measured the infrared response of $Mn_3Si_2Te_6$ across the magnetic ordering and field-induced insulator-to-metal transitions in order to explore colossal magnetoresistance in the absence of Jahn-Teller and double-exchange interactions. Rather than becoming a traditional metal with screened phonons, the field-driven insulator-to-metal transition leads to a weakly metallic state with localized carriers. The spectral data were fit using a percolation model which envisions "droplets" of metallicity embedded in an insulating matrix and the results provide evidence for electronic inhomogeneity and phase separation (droplets) in the material. Modeling also reveals a frequency-dependent threshold field for carriers contributing to colossal magnetoresistance which we discuss in terms of polaron formation, chiral orbital currents, and short-range spin fluctuations. These findings enhance the understanding of insulator-to-metal transitions in new settings and open the door to the design of unconventional colossal magnetoresistive materials.



(a) Reflectance ratios of $Mn_3Si_2Te_6$ as a function of magnetic field at 5.5 K. The appearance of new features at high fields is entirely due to changes in the electronic background and is almost totally decoupled from the lattice. (b) Crystal structure showing two distinct Mn sites. (c) Percolation threshold as a function of frequency, obtained from percolation model fits.

Facilities and instrumentation used: This research was conducted in the 17.5 Tesla, 52 mm Bore Magnet (SCM 3) at the DC Field Facility.

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