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Three-dimensional Anisotropy and Kohler's Rule Scaling of the Magnetoresistance in WTe_2[1]

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Tungsten ditelluride (WTe_2) was recently discovered to have extremely large magnetoresistance (XMR) at low temperatures and exhibits a transformative 'turn-on' temperature behavior: when the applied magnetic field H is above a certain value, the resistivity versus temperature $\rho(T)$ curve shows a minimum at a field dependent temperature $T^*(H)$. Since WTe_2 is a layered compound with metal layers sandwiched between adjacent insulating chalcogenide layers, it is typically considered to be a two dimensional (2D) material, whereby the anisotropic magnetoresistance is attributed only to the perpendicular component of the magnetic field. Moreover, the 'turn-on' temperature behavior has been interpreted as a magnetic-field-driven metal-insulator transition or attributed to an electronic structure change. In this talk I will report on two scaling behaviors of the magnetoresistance in WTe_2. The first shows that the angle dependence of the magnetoresistance follows a conventional 3D anisotropy scaling and hence reveals the electrical 3D nature of WTe_2 [1]. The second demonstrates that the $\rho(T, H)$ curves, including those with 'turn-on' temperature behavior, can be scaled with Kohler's rule [2]. The observed Kohler's rule scaling excludes the possible existence of a magnetic-field-driven metal-insulator transition or significant contribution of an electronic structure change to the low-temperature XMR in WTe_2. It indicates that both the XMR and the 'turn-on' behavior originate from the high mobilities of the charge carriers, which are strongly temperature dependent in WTe_2. We also derived quantitative expressions for the magnetic field dependence of the 'turn-on' temperature $T^*(H)$ and for the temperature dependence of the resistivity $\rho(T^*, H)$ at the onset of the XMR behavior.

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References:

[1] L. R. Thoutam, Y. L.Wang et al., Phys. Rev. Lett. 115, 046602 (2015)
[2] Y. L. Wang et al. Phys. Rev. B 92, 180402(R) (2015)

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