Persistence of Magnetism in Atomically Thin $MnPS_3$ Crystals

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The magnetic state of atomically thin semiconducting layered antiferromagnets such as CrI_3 and $CrCl_3$ can be probed by forming tunnel barriers and measuring their resistance as a function of magnetic field and temperature. This is possible because the spins within each individual layer are ferromagnetically aligned and the tunneling magnetoresistance depends on the relative orientation of the magnetization in adjacent layers. The situation is different for systems that are antiferromagnetic within the layers in which case it is unclear whether magneto- resistance measurements can provide information about the magnetic state. Here, we address this issue by investigating tunnel transport through atomically thin crystals of $MnPS_3$, a van der Waals semiconductor that in the bulk exhibits easy-axis antiferromagnetic order within the layers. For thick multilayers below T ~ 78 K, a T-dependent magnetoresistance sets in at μ_0H ~ 5 T and is found to track the boundary between the antiferromagnetic and the spin-flop phases known from bulk measurements. We show that the magnetoresistance persists as thickness is reduced with nearly unchanged characteristic temperature and magnetic field scales, albeit with a different dependence on H, indicating the persistence of magnetism in the ultimate limit of individual monolayers.

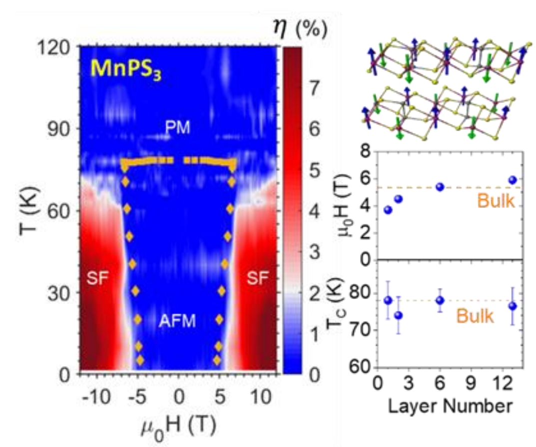

FIG. 1. Left Panel: Tunneling magnetoresistance η of a multilayer $MnPS_3$, as function of magnetic field and temperature. The values of the spin-flop field as a function of temperature (orange diamonds) and of the Neel temperature as a function of μ_0H (orange square) extracted from measurement on bulk crystals are overlaid on the same plot. Right Panel: Characteristic magnetic field and temperatures at which the magnetoresistance vanishes for all devices, as a function of layer number. The horizontal orange dashed lines indicate the bulk Neel temperature and spin-flop field in bulk $MnPS_3$, respectively. The top panel presents the magnetic structure of bulk $MnPS_3$.

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