Insulator-metal transitions in $TMPX_3$ van-der-Waals antiferromagnets

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The honeycomb two-dimensional antiferromagnets *TM*PS_3, where *TM* = Transition Metal such as Fe, Mn, Ni, V, form an ideal playground for tuning both low-dimensional magnetic and electronic properties. Electronically, these materials are all Mott insulators (see [1] for a review), with a wide range of band gaps from 0.2 to 3.5 eV across the family, and despite all sharing the same structure, these materials show a rich variety of 2D magnetic structures. The field of 2D magnetism is currently a very hot topic in condensed matter physics, with a flurry of high-impact publications, and the tuning of magnetic and electronic properties in such materials has exciting potential for new technological applications such as spintronics and a new generation of transistors.

I will present an overview of our work using high pressure as a continuous tuning parameter to control the dimensionality of these materials. Due to the weak physical inter-planar forces in such van-der-Waals materials, pressure gives us clean and selective control over the inter-planar spacing and hence interactions. I will present magnetic, structural and electrical transport results and compare the behaviour of Fe-, V-, Mn- and $NiPS_3$ as we tune them towards 3D structures.

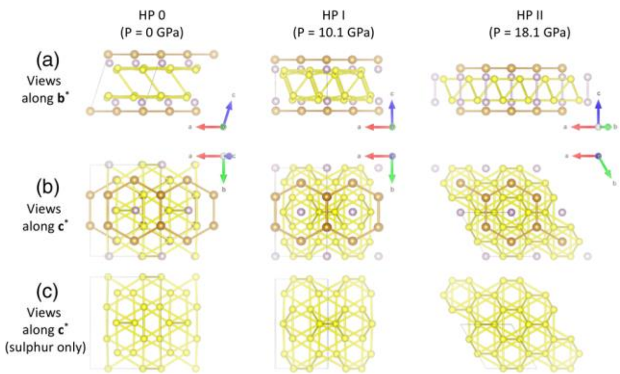

Figure 1. Structural evolution of $FePS_3$ with pressure. The second transition, to the HP-II phase, is accompanied by an insulator-metal transition.

Of particular interest is the contrast between the case of $FePS_3$ [2] and the near-unstudied VPS_3. We find 2 structural transitions with pressure common to the whole family, and link the second to an insulator-metal transition – except in the case of VPS_3 where we find the transition to be isostructural. Multiple puzzles persist in the very different transport and magnetotransport properties of Fe- and VPS_3.

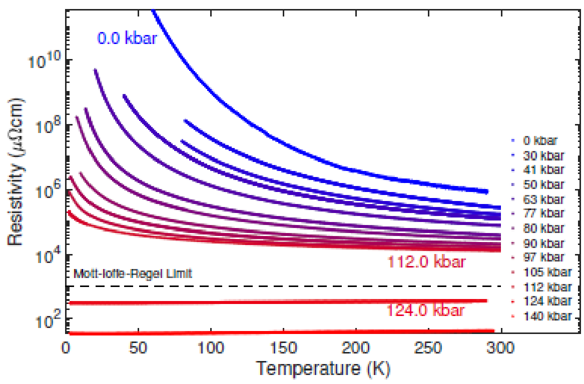

Figure 2. Insulator-metal transition in single-crystal VPS_3 as pressure is increased in a diamond-anvil cell.

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