Magnetic ordering of Co$_{1/3}$NbS$_2$ under pressure

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Abstract: Magnetic orderings driven by competing interactions on a frustrated lattice usually result in complex phase diagrams that are challenging to study. Intercalated Co atoms in the layered NbS$_2$ matrix form a triangular lattice and at ambient pressure Co$_{1/3}$NbS$_2$ exhibit an antiferromagnetic like order at 26 K. While the parent compound 2H-NbS$_2$ shows a pressure independent superconducting transition at 6 K, the hydrostatic pressure suppresses the magnetic ordering temperature in Co$_{1/3}$NbS$_2$ to zero at 2 GPa. The ordering mechanism is not fully understood, although those scenarios that include super-exchange and RKKY interactions are natural candidates.

Motivation

Co$_{1/3}$NbS$_2$ belongs to the family of intercalated transition metal dichalcogenides, where cobalt atoms are intercalated within the layer structure of the parent compound 2H-NbS$_2$, between metallic NbS$_2$ layers. While parent compound is superconducting, intercalated orders antiferromagnetically on the geometrically frustrated triangular lattice.

Since NbS$_2$ layers are weakly coupled, strong impact of the hydrostatic pressure on the magnetic ordering through influence on the interaction of localized Co spins and itinerant electrons is expected.

Pressure cell

- Two type of pressure cells:
  - Self-clamped piston-cylinder cell
    - pressures up to 3 Gpa
    - larger sample space
    - measurement of resistivity and magnetization
  - diamond anvil cell
    - pressures of the order of 30 Gpa
    - smaller sample space
    - measurement of resistivity

Transport at ambient pressure

Antiferromagnetic transition is clearly observed in transport properties[1] through a kink in electrical resistivity while thermopower is steepest at $T_N$ (Néel temperature).

Influence of pressure on the magnetic ordering

- first study of the effect of pressure on transition metal dichalcogenides (TMDs) intercalated by atoms that order magnetically

Elastic neutron scattering

- ILL (Grenoble),

Antiferromagnetic ordering vanishes with temperature below 26 K and with pressure below 1.7 GPa (at 10 K) confirming magnetic phase diagram envisaged from transport measurements.

Prospecstives

- detailed measurement of anisotropy
- transport properties in magnetic field -> real nature of interactions in system

References