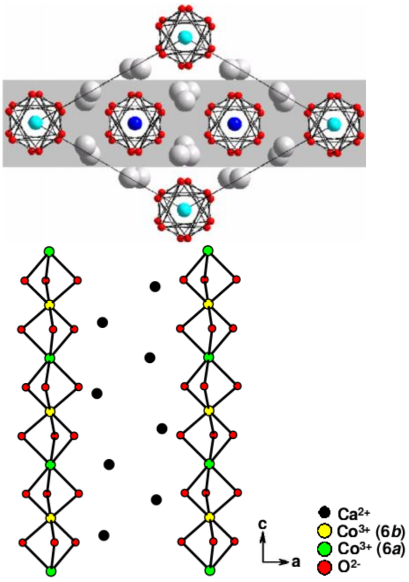
Correlated Electron Systems: Oxides/Intermetallics



Structure of a low dimensional oxide system studied extensively by us, $Ca_3Co_2O_6$

Welcome to our lab

Competing interactions plays a crucial role in controlling the physical properties of materials, making this field of research lively. In our laboratories, apart from focussing on discovering novel materials, we investigate how various phenomena of great current interest compete by changing temperature, external and chemical pressure, magnetic fields and particle size. Some of the topics of current interest are: (i) Competition between magnetic ordering and the Kondo effect (in the field of "Heavy fermions"), which favours non-magnetism; (iii) Competition between magnetism and ferroelectricity ("multiferrocity"); (iii) What happens to the spins arranged in a triangular fashion which are coupled antiparallel to each other (leading to what is known as "geometrically frustrated magnetism")? A comparison of the properties of materials in bulk and single-crystalline forms with those of nanocrystals has been found to be valuable to understand some of the issues in the field. Apart from these, topics relevant to applications like magneto-caloric effect are also being undertaken.

Tools & Techniques

We have facilities to synthesize the materials in bulk form, single crystal and nanoform. Many experimental facilities down to subhelium temperatures and high magnetic fields exist in our laboratories - heat-capacity, magnetization, electrical resistivity thermopower, complex dielectric properties and electric polarization and Mössbauer spectroscopy. In addition we collaborate with other labs for studies like neutron diffraction, Raman and Photoelectron spectroscopy. Several department facilities like TEM, SEM, XRD are available for characterizing the materials. We also specialize in performing electrical resistivity and magnetization under high pressure.

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Highlights

The *f-electron anomalies in bulk form:*

Evidence for the validity of spin-density-wave picture (as against 'local-moment' picture) as quantum critical-point is approached - a major issue in the field of 'heavy-fermions', (PRB 82, 104428 (2010)). Anomalous magnetic ordering in a Nd-based intermetallic compound, emphasizing the need to explore strong electron correlation effects in Nd systems (PRB 84, 184415 (2011)).

Huge enhancement of magnetoresistance, with *a positive sign* which is unexpected at the metamagnetic transition; possible 'Inverse metamagnetism', an interesting new concept (e.g., PRB 79, 060403(R) (2009); PRB 80, 214425 (2009); PRB 81, 184434 (2010)).

Particle-size effects in intermetalics:

First demonstration of particle-size induced ferromagnetism in an exchange-enhanced "Pauli paramagnet" like YCo_2. Interestingly, f-electron electron localization leading to magnetic ordering has been reported even for (non-magnetic) Kondo lattice. (APL 92, 192506 (2008); PRB 80, 024401 (2009)).

Spin-chain magnetism:

Identification of anisotropic spin-glass anomalies and spin-chain magnetism (Tb_2PdSi_3), unusual among among intermetallics (PRB 67, 212401 (2003)).

Magnetoelectric coupling and multiferroicity in a Haldane spin-chain system (PRB 88, 094438 (2013)).

In $Ca_3Co_2O_6$ and its derivatives, we reported evidence for hitherto unrealized 'incipient' spin-chain ordering at a temperature much higher than Néel temperature, coupled with phonon and magnon anomalies! A rare phenomenon of "spin-chain-induced multiferroicity", that too, above 77 K, was discovered bearing relevance to applications (PRB 77, 172403 (2008); 79, 094103 (2009); JAP 108, 103517 (2010); (Nature Group) Sci. Rep. **3,** 3104 (2013).