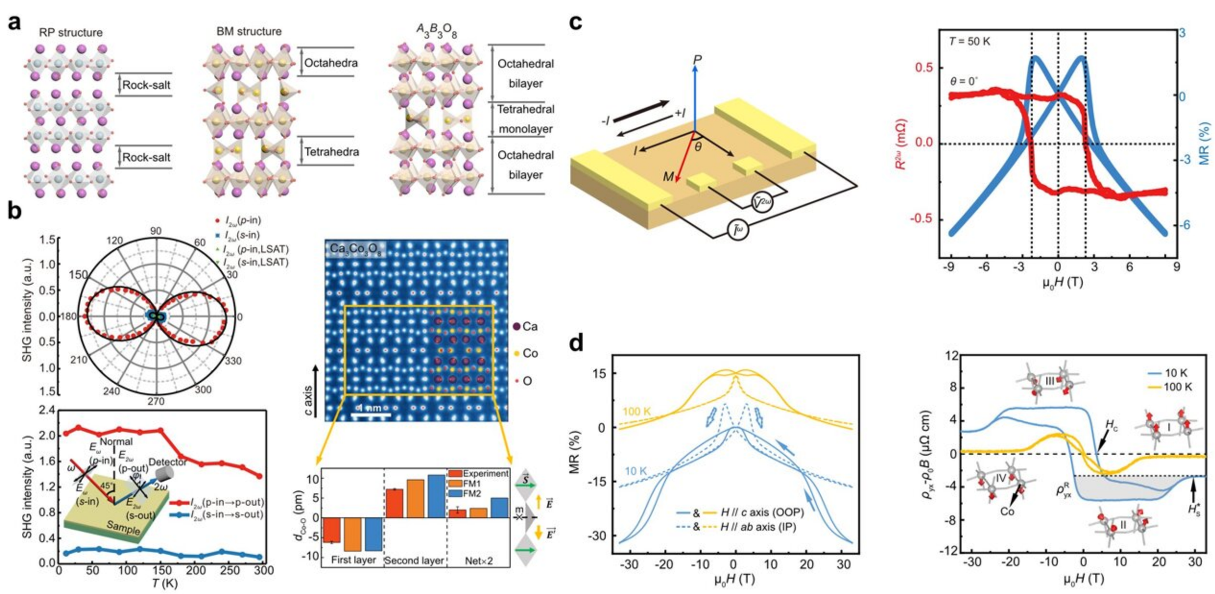
Researchers find high magnetic field facilitates novel intrinsic ferromagnetic polar metals

May 29 2024, by Zhao Weiwie; Hou De



Design and realization of intrinsic ferromagnetic polar metal state. Credit: Hou De

Researchers have designed a novel oxide material, $Ca_3Co_3O_8$, through atomic precision manipulation of correlated oxides. It demonstrated a remarkable combination of properties—ferromagnetism, polar distortion and metallicity, which shines a spotlight on polar metals and sparks significant scientific interest.

This achievement was published in *Nature Materials*. The collaboration included Prof. Sheng Zhigao from Hefei Institutes of Physical Science (HFIPS) of the Chinese Academy of Sciences (CAS), Professor Yu Pu's team from Tsinghua University, and users of the Steady High Magnetic Field Facility (SHMFF) at HFIPS.

In traditional understanding, electric polarization and magnetic order in materials were seen as mutually exclusive. However, the concept of polar metals was proposed, suggesting that these materials could exhibit both electric polarization and metallic properties simultaneously.

Integrating ferromagnetism into polar metals remains a challenge, as it involves reconciling the inherent contradiction between polarization, ferromagnetism, and metallicity within a single material, posing a significant scientific hurdle.

In this study, researchers explored the use of oxygen polyhedra to control material properties, leading to the creation of a new quasi-two-dimensional functional oxide named $Ca_3Co_3O_8$. This material combines features from the double-layer Ruddlesden-Popper (RP) structure and brownmillerite (BM) structure.

They used the SHMFF's nonlinear optical testing system to confirm significant polarization ordering in $Ca_3Co_3O_8$. They found that the displacement of Co ions in the double-layer CoO6 octahedron was the main contributor to the polarity.

Leveraging the SHMFF's water-cooled magnet system for electrical transport testing, the team also observed a significant topological Hall effect in the material.

These results provide an ideal material platform for the exploration of electric and magnetic correlated properties and offer a novel perspective for the design of correlated oxides.

The robust topological Hall effect in this material not only advances understanding of magnetic materials and interactions but also offers potential for foundational research and application exploration in spintronics, according to the team.

More information: Jianbing Zhang et al, A correlated ferromagnetic polar metal by design, *Nature Materials* (2024). DOI: 10.1038/s41563-024-01856-6

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