Cupric oxide exhibiting both magnetic and dielectric properties at room temperature

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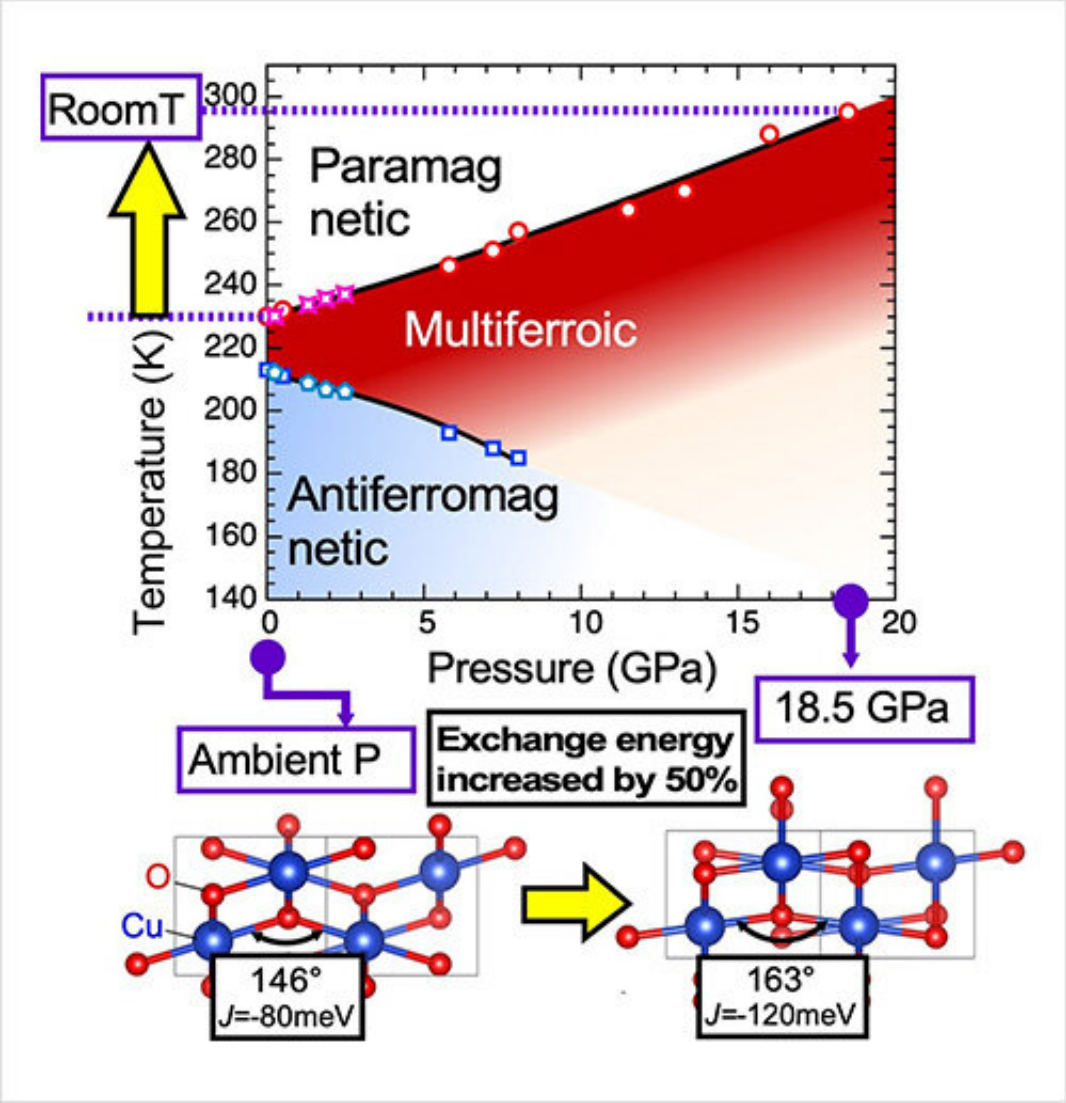

When a cupric oxide compound is subjected to high pressure, its Cu–O–Cu bond angle widens, strengthening the magnetic interaction between the ions. Using this phenomenon, this research team experimentally confirmed that the compound is

able to exhibit its multiferroic state at room temperature. Credit: National Institute for Materials Science

The National Institute for Materials Science (NIMS), the Rutherford Appleton Laboratory in the U.K. and the University of Oxford in the U.K. have experimentally confirmed that a cupric oxide exhibits multiferroic state (i.e., both magnetic and ferroelectric properties) at room temperature under high pressure.

The theoretical model constructed in this research is expected to facilitate the development of next-generation memory devices and optical modulators.

Multiferroic materials are potentially applicable to the development of next-generation memory devices and energy-efficient optical modulators. However, because most of these materials are functional only at temperatures below 100 K, scientists had worked for years to make them exhibit multiferroic properties at room temperature—a requirement for devices that need to operate at ambient temperatures.

This research team focused on cupric oxide—a multiferroic material—because when it is subjected to high pressure, the copper and oxide ions constituting it change their positions relative to each other, significantly increasing the magnetic interactions between them. Due to this phenomenon, it had been theoretically suggested to be able to exhibit multiferroic properties at room temperature. However, this had not been experimentally confirmed due to the inability to directly measure atomic spin (i.e., atomic-level magnetism) under high pressure.

The research team developed a high-pressure generator which also enables the measurement of atomic spin under high pressure. Using this

apparatus, the team confirmed through neutron diffraction experiments that cupric oxide is able to exhibit multiferroic state at room temperature under high pressure.

In addition, NIMS developed a new calculation method and used it to build a theoretical model which is expected to facilitate the development of room-temperature multiferroic materials. This calculation method was designed to operate effectively without requiring a large number of predetermined assumptions related to the strength of the magnetic interactions taking place between specific copper ions under high pressure.

The cupric oxide compound is able to exhibit its room-temperature multiferroic state only when subjected to a high pressure of 18.5 GPa (185,000 atm). Thin films composed of precisely distorted crystals grown in accordance with the theoretical model may potentially be able to exhibit such properties at ambient atmospheric pressure.

This research was published in the online version of *Physical Review Letters* on November 15, 2022.

More information: Noriki Terada et al, Room-Temperature Type-II Multiferroic Phase Induced by Pressure in Cupric Oxide, *Physical Review Letters* (2022). DOI: 10.1103/PhysRevLett.129.217601

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