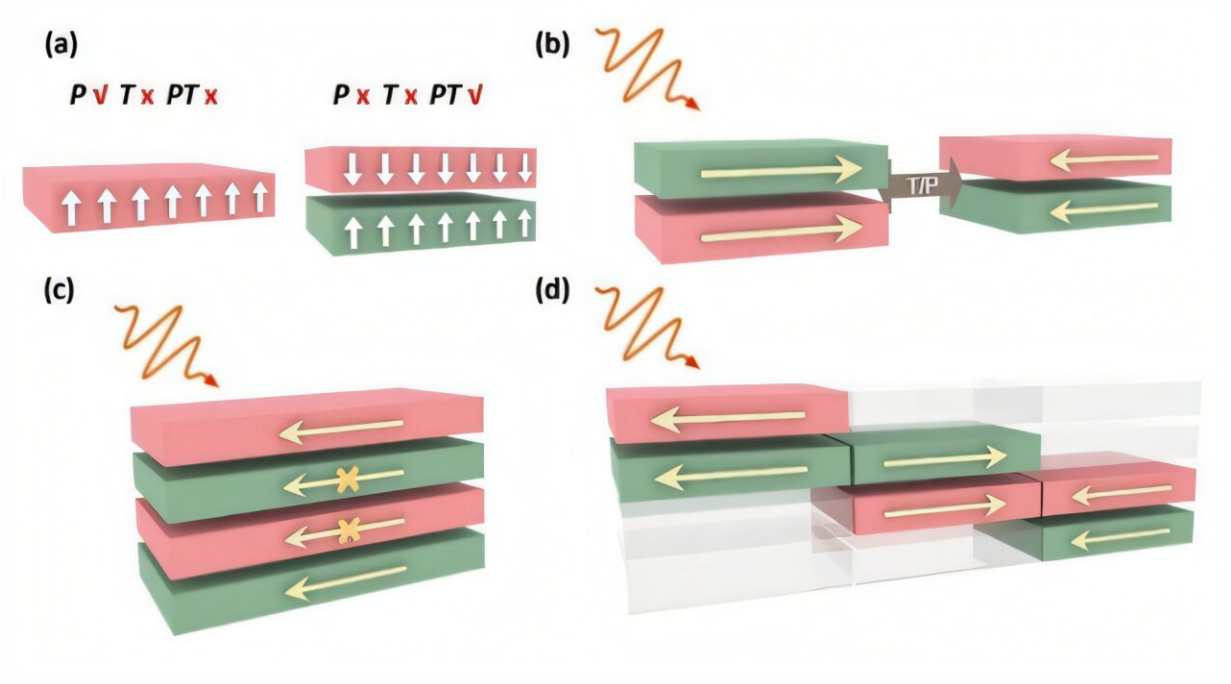
Nonlinear 'skin effect' unveiled in antiferromagnetic materials

December 18 2024, by Shao Dingfu and Zhao Weiwei



Credit: Shao Dingfu

A team of researchers has identified a unique phenomenon, a "skin effect," in the nonlinear optical responses of antiferromagnetic materials. The research, published in *Physical Review Letters*, provides new insights into the properties of these materials and their potential applications in advanced technologies.

Nonlinear optical effects occur when light interacts with materials that lack inversion symmetry. It was previously thought that these effects were uniformly distributed throughout the material. However, the research team discovered that in antiferromagnets, the nonlinear optical response can be concentrated on the surfaces, similar to the "skin effect" seen in conductors, where currents flow primarily on the surface.

In this study, the team developed a self-designed computational method to investigate the nonlinear optical responses in antiferromagnets, using the bulk photovoltaic effect as a representative example. Their results showed that, while the global inversion symmetry was broken, the local inversion symmetry deep inside the antiferromagnet was almost untouched.

As a result, the nonlinear optical response was primarily confined to the top and bottom surfaces of the antiferromagnet, with negligible contribution from its interior.

To demonstrate the findings, the researchers conducted first-principles calculations on the two-dimensional antiferromagnet CrI_3, confirming the surface-dominant behavior of the bulk photovoltaic effect. Additionally, they calculated the second-harmonic generation effect, finding consistent results with their theoretical models.

The discovery of the skin effect in nonlinear optical responses opens exciting opportunities for both the fundamental sciences and the optoelectronic technology. "It offers a new perspective on how nonlinear optical effects can be utilized in high-performance device applications," said Prof. Shao Dingfu from the Hefei Institutes of Physical Science of the Chinese Academy of Sciences.

More information: Hang Zhou et al, Skin Effect of Nonlinear Optical Responses in Antiferromagnets, *Physical Review Letters* (2024). DOI:

10.1103/PhysRevLett.133.236903