Natural material discovered that exhibits in-plane hyperbolicity

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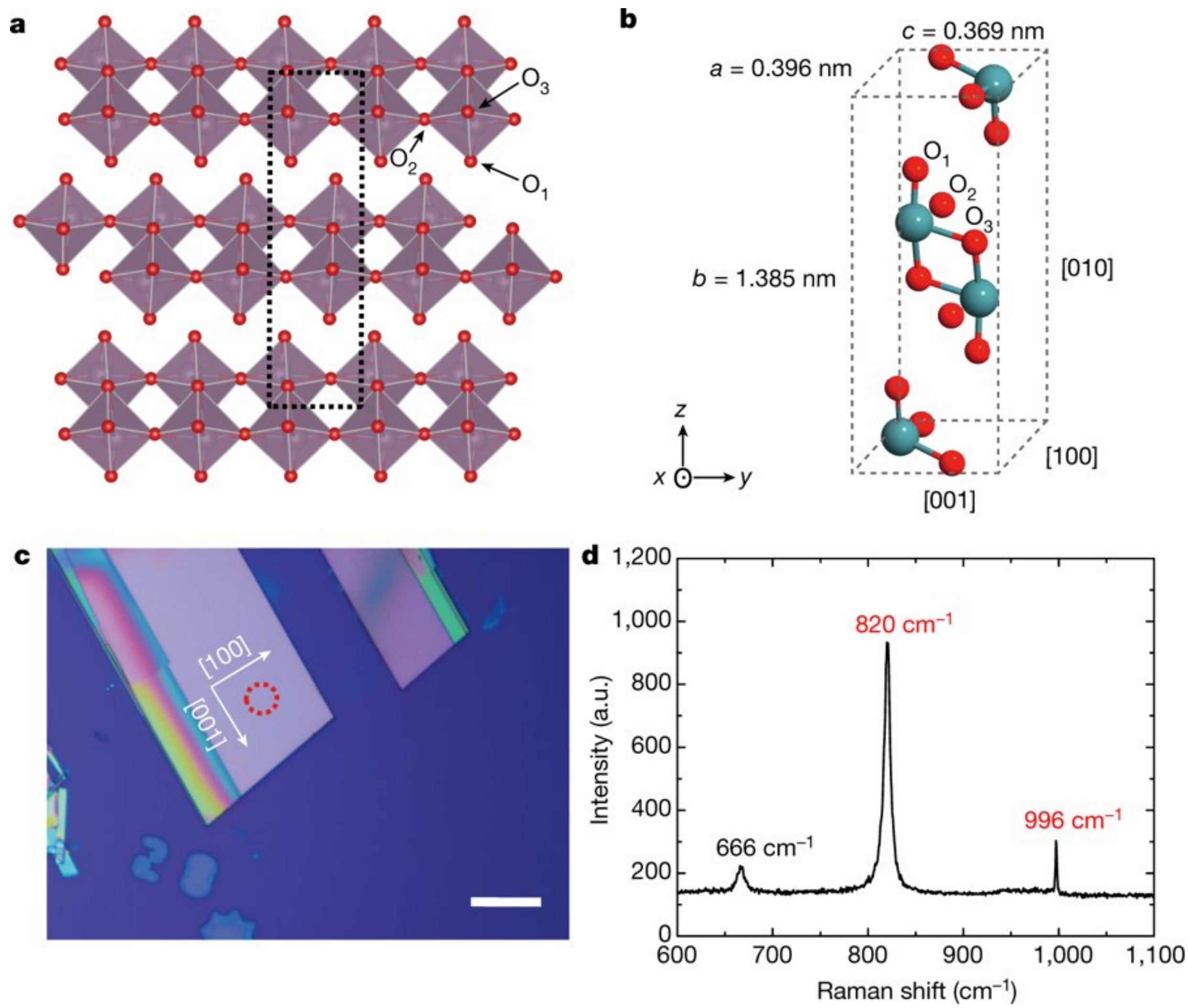

a, Illustration of the orthorhombic lattice structure of layered α-MoO3 (red spheres, oxygen atoms). The orthorhombic structure is based on bilayers of distorted MoO6 octahedra stacked along the [010] direction via vdW interactions. The three possible positions of oxygen atoms are denoted O1–3, and the unit cell is shown dashed. b, Schematic of the unit cell of α-MoO_3; the lattice constants are a = 0.396 nm, b = 1.385 nm and c = 0.369 nm. Blue spheres, molybdenum atoms. c, Optical image of α-MoO_3 flakes. The α-MoO_3 crystals typically appear to be rectangular owing to the anisotropic crystal structure. Labelled arrows indicate crystal directions. Scale bar, 20 μm. d, Raman spectrum taken in the area marked by a red dashed circle in c. Red frequency labels indicate the Raman peaks associated with the lattice vibrations producing the RBs of α-MoO_3. Credit: (c) *Nature* (2018). DOI: 10.1038/s41586-018-0618-9

An international team of researchers has discovered a natural material that exhibits in-plane hyperbolicity. In their paper published in the journal *Nature*, the group describes their work with molybdenum trioxide and what they found. Thomas Folland and Joshua Caldwell with Vanderbilt University offer a News and Views piece on the work done by the team in the same journal issue.

As Folland and Caldwell note, hyperbolic materials are those that are extremely reflective to light along one axis and have normal reflectance along another axis. In most such materials, the two axes are not on the same plane. But as Folland and Caldwell further note, a material in which they are in the same plane would be valuable because it could serve as a very thin waveplate—materials that alter the polarization of the light that strikes it. They point out that such a waveplate could allow researchers to manipulate wavelengths at a very small scale. In this new effort, the researchers report the discovery of just such a material—a natural one called molybdenum trioxide.

Folland and Caldwell point out that there was a time in the not-too-distant past when it was believed that hyperbolicity only existed in man-made materials. But just four years ago, it was observed in hexagonal boron nitride. It was also determined that the reflective behavior of such materials came about due to vibrations in their crystal lattice, i.e. optical phonons. Such phonons were found to have long lifetimes, which served to prevent the absorption of light. Over the past few years, a number of natural hyperbolic materials have been found.

Prior work had shown that molybdenum trioxide was hyperbolic for longwave infrared light. In this new effort, the researchers have shown that it also exhibits in-plane hyperbolicity. They used their finding to confine light in ways that were smaller than its wavelength using hyperbolic phonon polaritons. The lifetimes for the polaritons were found to be approximately 10 times longer than for hexagonal boron nitride.

Folland and Caldwell suggest the unique properties of molybdenum trioxide could break new ground in developing nanophotonics. They also note that it has been theorized that hyperbolic materials could be used to create hyper-lenses or heterostructures.

More information: Weiliang Ma et al. In-plane anisotropic and ultra-low-loss polaritons in a natural van der Waals crystal, *Nature* (2018). DOI: 10.1038/s41586-018-0618-9

Thomas G. Folland et al. Precise control of infrared polarization using crystal vibrations, *Nature* (2018). DOI: 10.1038/d41586-018-07087-5

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