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Chiral thermal emission becomes a reality through twisting

ICFO researchers have generated circularly polarized mid-infrared light through incandescence, which could be used to probe the chiral properties of materials. By employing twisted low-dimensional bilayers, the team introduces a new paradigm to light generation and polarization control in the mid-infrared, removing the need to directly pattern the material's surface via lithography.

The approach, presented in Nature Communications, makes the process simpler and potentially cost-effective. This could be especially useful for sensing, pharmaceutical analysis and material identification.

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Chirality, that geometrical property preventing our left and right hands from matching each other even if we rotate or flip them, is at the heart of life as we know it. Molecules, elementary particles, and even light can possess chiral properties, making the ï¿½leftï¿½ counter
art intrinsically different from the ï¿½rightï?
½ one. In nature, however, chirality is very weak. Enhancing and tailoring it can t
us meet technological needs in spectroscopy, medicine, pharmaceutics, and sen
ing. In pharmaceutics, for instance, chiral light enables the distinction between ena
tiomers (molecules that are mirror images of each other), one of which may be therape
tically effective while the other can be inactive or even harmful. To achieve this, one must
enerate left- and right-circularly polarized light and observe how the sample absorbs them diff
rently, an absorption that typically occurs in the mid-infrared frequency range, where chir
l light sources are particularly
scarce. Now, ICFO researchers **Dr. Michael T. Enders**, **Dr. Mitradeep Sarkar**, **Evgenia Klironomou**, **Dr. Michela Florinda Picardi**, **Riccardo Bertini**, and **Aleksandra Deeva**, led by **Prof. at ICFO Georgia T. Papadakis**, have presented in Nature Communications a fundamentally different and **significantly simpler approach to generating mid-infrared chiral light** compared with previous state-of-the-art techniques. The method is based on the anisotropic properties (meaning that its interaction with light changes depending on the direction in which it is measured) of a low-dimensional material called alpha molybdenum trioxide (?-MoO3). This

feature enabled researchers to induce chirality **without employing external polarization elements** and **without directly patterning the material's surface** via lithography, as previously required.

To achieve such a milestone, the team exfoliated, stacked and twisted low-dimensional bilayers of ?-MoO3. The researchers then showed that the bilayers absorbed left- and right-circularly polarized light differently, highlighting its chiral behavior. Next, they heated the samples, which, due to their high temperature, naturally emitted infrared radiation through incandescence. After analyzing the radiation's polarization, they discovered that it was already circularly polarized, unlike the incoherent nature of blackbody radiation.

ï¿½The results demonstrate that simply twisting a-chiral materials yields chirality, and th s chirality can manifest even in thermal emission, which is by nature incoherent and a-chir l with conventional materialsï¿½, says Prof. Georgia Papadakis, lead researcher of the st dy. ï¿½The conventional wisdom until now has been that tailoring thermal emiss on and engineering a such chiral response required **metamaterials** or **photonic crystals**; these are more complex nano- and micro-structures that are more challenging to both fabricate and understand.ï¿

? As a consequence of this paradigm shift, the obtained mid-infrared chiral light sources a e ultra-compact (a few microns thick) and potentially suited for on-chip integration. ï¿½T ese twisted bilayers of ?-MoO3 serve as miniaturized mid-infrared light sources that operate based on incandescence, a cheap and scalable mechanism for future mid-IR lighting,ï¿

? explains Prof. Papadaki

. Chiral mid-infrared lighting finds applications in sensing, pharmaceutical analysis a d material identification. ï¿½A major goal now is how to use our platform to amplify weak ch ral signals from molecules, enabling more sensitive detection schemes,ï¿½ adds the prof

Reference:

Enders, M.T., Sarkar, M., Klironomou, E. et al. Mid-infrared chirality and chiral thermal emission from twisted ?-MoO3. Nat Commun **16**, 11086 (2025).

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