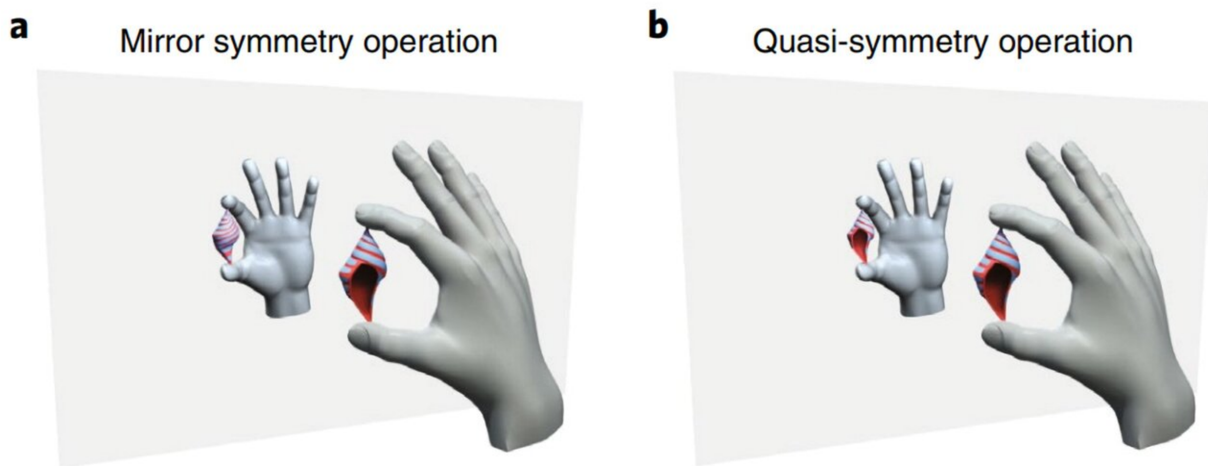
Quasi-symmetry in CoSi reveals new type of topological material

May 19 2022



Comparison between a mirror symmetry and quasi-symmetry operation. A mirror symmetry operation consistently acts on the whole object. In contrast, the quasi-symmetry operation acts differently on different parts of the system. Credit: MPSD / Dept. Microstructured Quantum Matter

Ever since the discovery of the quantum Hall effect (Nobel Prize 1985), symmetry has been the guiding principle in the search for topological materials. Now an international team of researchers from Germany, Switzerland, and the U.S. has introduced an alternative guiding principle, "quasi-symmetry," which leads to the discovery of a new type of topological material with great potential for applications in spintronics and quantum technologies. This work has been published in *Nature*

Physics.

As distinct from a proper symmetry which acts on the whole object uniformly, the quasi-symmetry operation acts selectively on different parts of the system. A simplified example may be an incomplete mirror image, in which some parts of the object are mirrored but others are not. Theoretically, it corresponds to a system that has exact symmetry when taking only the basic approximation into consideration while additional approximative terms break such symmetry. In the electronic band structure of a solid, this enforces finite but parametrically small energy gaps at some low-symmetry points in momentum space.

In their new work, the researchers demonstrate that quasi-symmetry in the semi-metal CoSi stabilizes tiny energy gaps over a large near-degenerate plane. This is reflected in the way the electrons are bent into circular motion by a magnetic field, known as quantum oscillations. The application of in-plane strain breaks the crystal symmetry which gaps only the corresponding degenerate points but the quasi-symmetry-protected points remain intact, observable by new magnetic breakdown orbits. These results demonstrate one of the most important features of quasi-symmetry: its robustness against chemical and physical perturbations.

Most of the topological materials discovered in recent years require precise engineering of their chemical composition for them to be relevant for future technological applications. In contrast, quasi-symmetries eliminate the need for such fine tuning as the topological features can be found at any arbitrary chemical potential. Moreover, quasi-symmetry-protected topological materials are robust against any physical deformation which breaks the crystalline symmetry. Moreover, quasi-symmetry-protected topological materials are robust against physical deformations which break the crystalline symmetry, a key prerequisite for their technological application via thin-film processes.

These features demonstrate a new class of topological materials with increased resilience to perturbations, which simplifies their use in technology. The researchers believe that this first example represents an important step towards uncovering topological materials beyond the usual space group classifications, which could help the community not to overlook what may be hidden in plain sight.

More information: Chunyu Guo et al, Quasi-symmetry-protected topology in a semi-metal, *Nature Physics* (2022). DOI: 10.1038/s41567-022-01604-0

Provided by Max Planck Institute for the Structure and Dynamics of Matter