New spin directions in pyrite an encouraging sign for future spintronics

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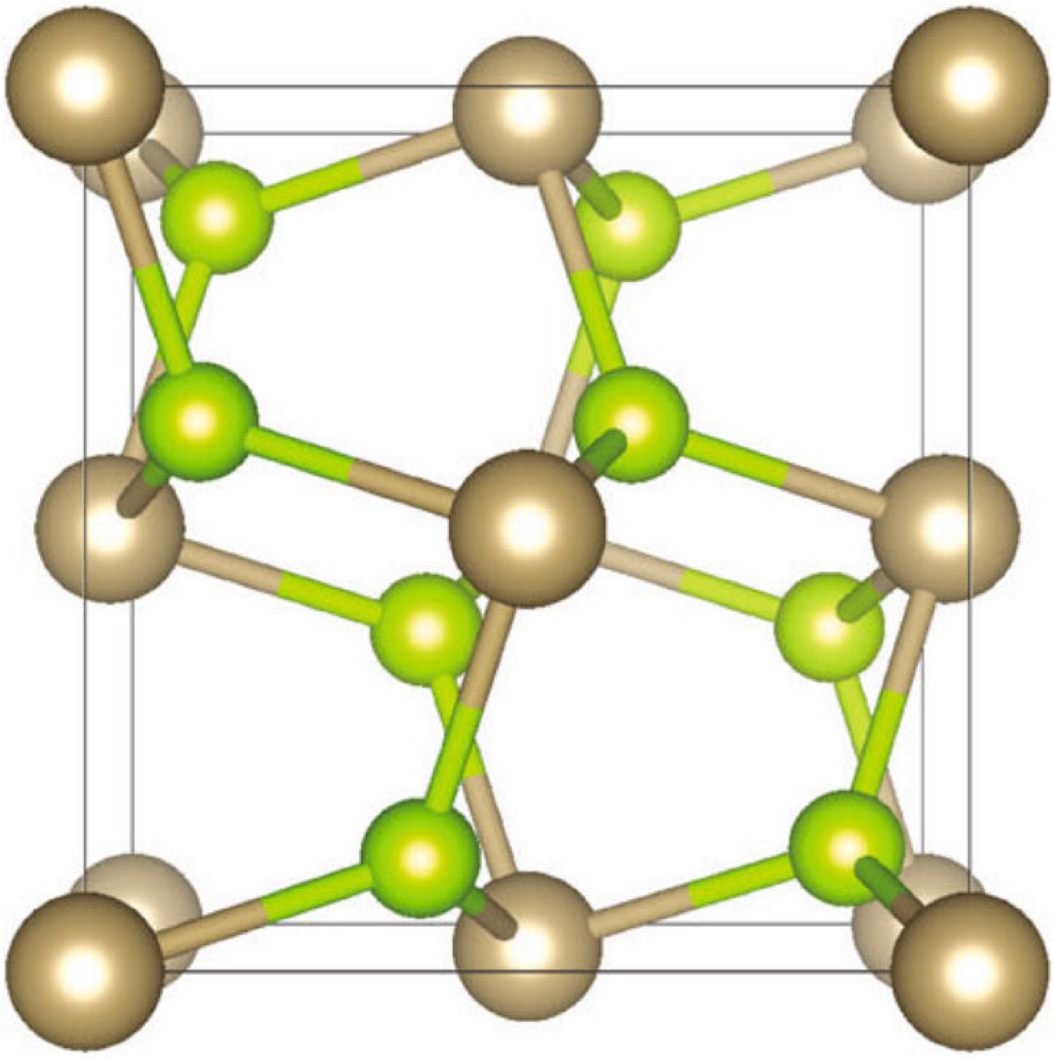

Crystal structure of Pyrite $OsSe_2$/$OsTe_2$. Credit: FLEET

A Monash University study revealing new spin textures in pyrite could unlock these materials' potential in future spintronics devices.

The study of pyrite-type materials provides new insights and opportunities for selective spin control in topological spintronics devices.

Seeking new spin in topological materials

Topological materials have exciting potential for next-generation, ultra-low energy electronics, including thermoelectric and spintronic devices.

However, a restriction on the use of such materials in spintronics has been that all topological materials studied thus far have spin states that lie parallel to the plane of the material, while many/most/all practical spintronic devices would require out-of-plane spin states.

Generating and manipulating out-of-plane spins without applying an external electric or magnetic field has been a key challenge in spintronics.

The new Monash Engineering study demonstrates for the first time that pyrite-type crystals can host unconventional energy- and direction-dependent spin textures on the surface, with both in-plane and out-of-plane spin components, in sharp contrast to spin textures in conventional topological materials.

"A number of pyrite-type materials have previously been theoretically predicted to show the desired out-of-plan spin textures," explains lead author Dr. Yuefeng Yin, in Monash Engineering's Computational Materials Lab.

Pyrite (colloquially known as 'fool's gold') is an iron-sulfide mineral that displays multiple internal planes of electronic symmetry.

"The presence of strong local symmetry protects out-of-plan spin states," explains Yuefeng, "so we decided to look closer at some of these crystals."

The unconventional spin texture discovered opens new possibilities for the necessary task of injecting or detecting out-of-plane spin component in future topological spintronic devices.

The study

Selective control of surface spin current in topological pyrite-type OsX2 (X = Se, Te) crystals was published in NPJ Quantum Materials in August 2019.

Using first-principles calculations, the Monash team separated surface spin states by their interactions with spin states in the bulk of the material, resulting in highly anisotropic but tunable behaviour.

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The link between symmetry and topological materials

The presence of strong, local symmetry provides topological robustness to spin states, and symmetry is therefore a strong predictor of topological behaviour, so that studying these phenomena in pyrite crystals should provide clues towards discovery of many other new topological materials
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Topological insulators are novel materials that behave as electrical insulators in their interior, but can carry a current along their edges. Unlike a conventional electrical path, such topological edge paths can carry electrical current with near-zero dissipation of energy, meaning that topological transistors can switch without burning energy.

More information: Yuefeng Yin et al. Selective control of surface spin current in topological pyrite-type OsX2 (X = Se, Te) crystals, *npj Quantum Materials* (2019). DOI: 10.1038/s41535-019-0186-8

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