Researchers realize the quantum simulations of topological phase transitions

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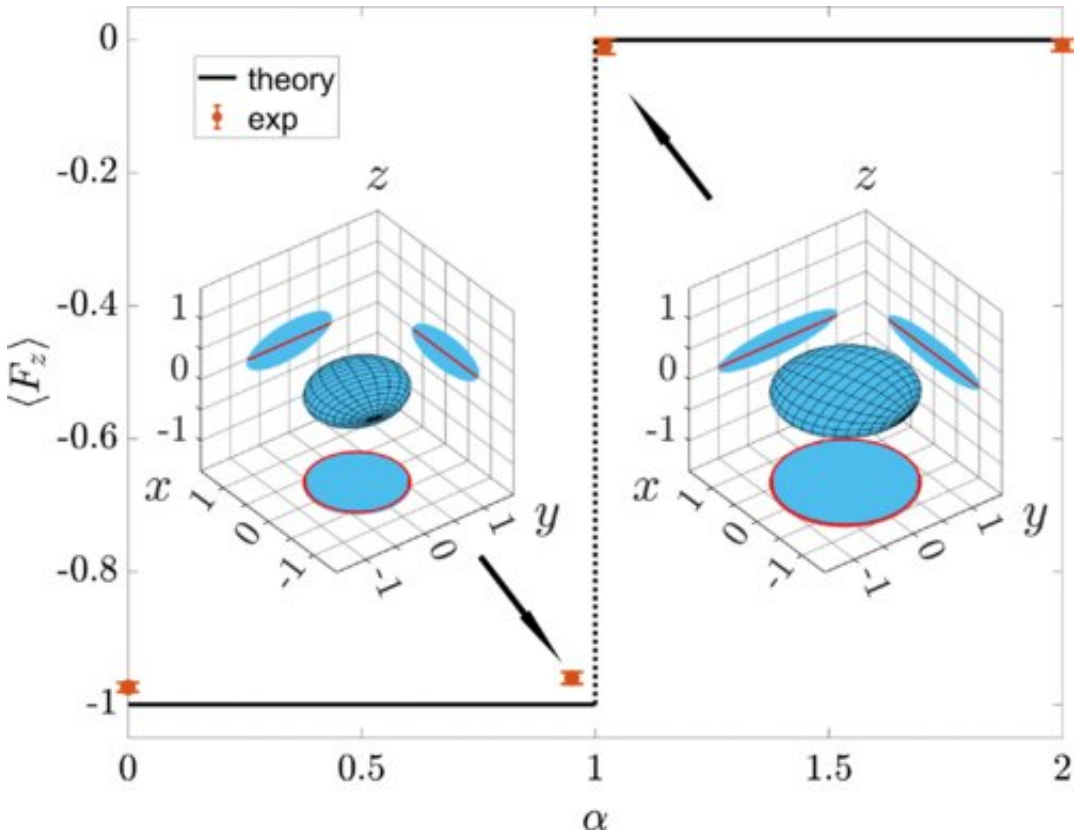

Phase transition characterized by the jump of spin vector and tensor. Credit: Zhang Mengxiang et al

Topology refers to the overall property that remains unchanged despite continuous local modifications. A coffee cup and a donut are no different to mathematicians because they have the same topological

charge. Materials with various topological charges display diverse properties. Exploring phase transitions between different topological states brings prospects for novel materials and new physics.

Recently, a research team led by Prof. Du Jiangfeng, Prof. Lin Yiheng, and Prof. Luo Xiwang from the University of Science and Technology of China (USTC) of the Chinese Academy of Sciences (CAS) experimentally observed the phase transitions between triply degenerate points (TDPs) with different topological charges through highly controllable quantum simulations. The study was published in *Physical Review Letters*.

The researchers performed quantum simulations of topological phase transitions between TDPs in fermionic systems. Through a three-level trapped Be^+ ion driven by ratio frequency and microwave fields, a spin-1 quantum state is obtained. By tuning spin-tensor-momentum coupling strengths, the researchers observed the topological phase transitions of the quantum states and illuminated the important roles played by the spin tensors.

While building the multilevel trapped ion systems, the research team developed various technologies to study high-spin physics. They prolonged coherence time by an order of magnitude via dynamical decoupling. Furthermore, they also realized swift quantum control techniques on a four-level trapped ion system through analytical models. These previous efforts laid the foundation for the current research.

The study paved the way for future exploration of novel topological phenomena. The reviewer paid high praise and noted that "...importantly, the spin-tensor-momentum-coupling could be generated for spin-1 systems and induce intriguing quantum phenomena different from spin-1/2 ones. This work is of interest and importance."

More information: Mengxiang Zhang et al, Observation of Spin-Tensor Induced Topological Phase Transitions of Triply Degenerate Points with a Trapped Ion, *Physical Review Letters* (2022). DOI: 10.1103/PhysRevLett.129.250501