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Direct Observation of Quadruple Spin-texture Locking in a 2D d-wave Altermagnet

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Altermagnets combine vanishing net magnetization with nonrelativistic, momentum-dependent spin splitting, offering a new paradigm for spintronics. Spin-crystal symmetry coupling—namely spin-lattice locking—is the defining mechanism of altermagnetism, enforcing opposite spin sublattices in real space and spin-momentum-locked electronic structure in reciprocal space [1]. Direct atomic-scale visualization of spin-lattice locking therefore constitutes a decisive benchmark of the altermagnetic state; yet such evidence has remained elusive despite extensive efforts. In this talk, we show, using spin-polarized scanning tunnelling microscopy, that the electronic states in RbV2Se2O exhibit a d-wave-like spin texture at the sublattice level, providing the first atomic-scale evidence of spin-lattice locking [2]. By employing an in-situ, field-switchable spin-polarized Cr tip, we realize spin-contrast mapping of quasiparticle interference at identical energies, overcoming a long-standing experimental barrier in altermagnets. The resulting interference patterns exhibit pronounced spin-dependent modulations, establishing spin–scattering locking and spin–momentum locking as its real and reciprocal space manifestations, respectively. Unexpectedly, we uncover that the spin-selective scattering response is organized by a long-period stripe modulation, giving rise to a previously unidentified form of spin-texture locking—spin-stripe locking. We attribute this behavior to the emergence of a spin-density-wave moiré pattern. Together, these results establish a unified picture of quadruple spin-texture locking phenomena in a d-wave altermagnet, and position altermagnets as a versatile platform for exploring many-body interactions among intertwined degrees of freedom, including spin, lattice, momentum, moiré potential and valley.

References:

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