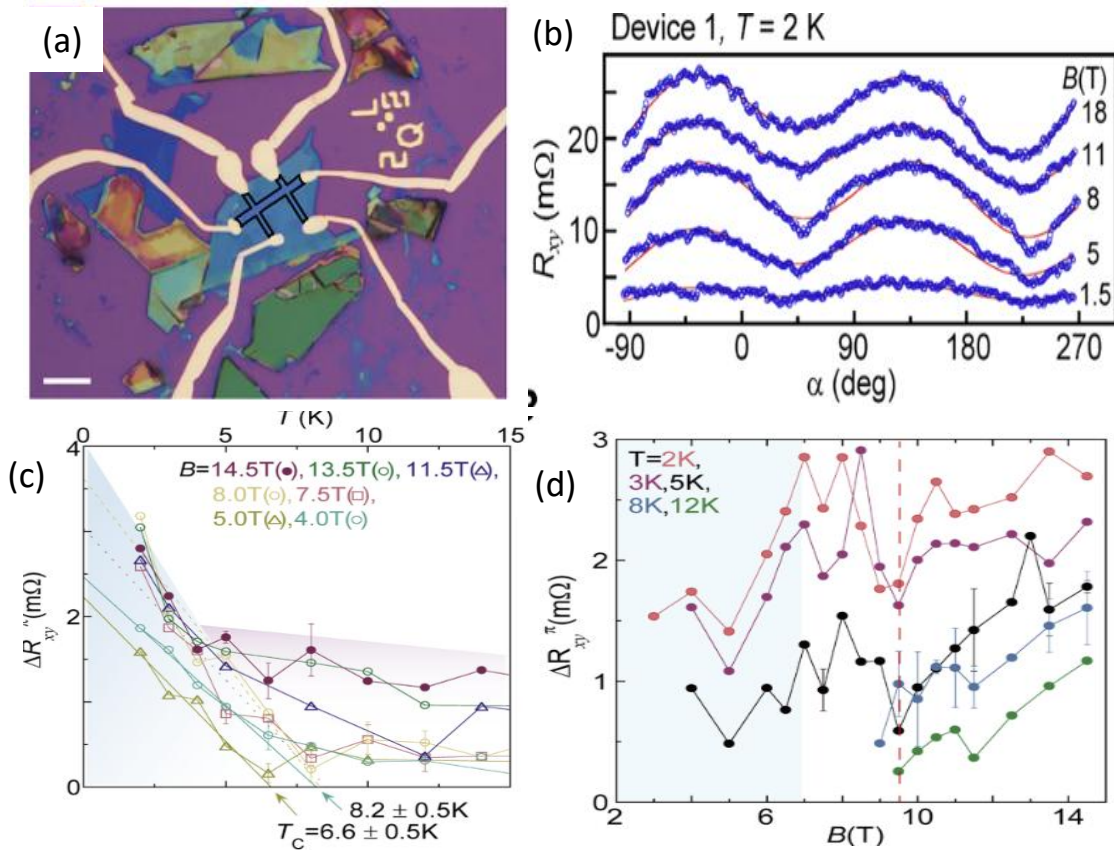


Electrical Detection of Spin Anisotropy in a Kitaev Spin Liquid Candidate α -RuCl₃



(a) Single crystal of RuCl₃ with Pt Hall bar deposited and leads attached, **(b)** R_{xy} Hall data showing an enhancement of oscillations close to $H_c = 8$ T where spin-liquid occurs, **(c-d)** The amplitudes of R_{xy} showing its evolution with temperature and field, capturing the energy scale of the Ising fluctuating moments related to the bond-dimensional Ising Kitaev model.

Unveiling field-transverse spin anisotropy in the spin liquid candidate α -RuCl₃ via spin Hall magnetoresistance, H. Idzuchi, M. Kimata, S. Okamoto, P. Laurell, N. Mohanta, M. Cothrine, S.E. Nagler, D.G. Mandrus, A. Banerjee, Y.P. Chen., Newton <https://doi.org/10.1016/j.newton.2026.100505> (Cell Press) 2026.

Scientific Achievement

- Demonstrated the electrical detection of magnetic correlations in a Kitaev quantum spin liquid candidate (α -RuCl₃) using spin Hall magnetoresistance (SMR) in an α -RuCl₃/Pt heterostructure.
- Discovered a \mathbf{B} -transverse spin anisotropy for all phases of α -RuCl₃ above 2 T.
- Two distinct anisotropy energy scales identified from temperature-dependent SMR, providing constraints on the α -RuCl₃ Hamiltonian.

Significance and Impact

- Establishes spin-sensitive transport as a practical electrical probe of insulating QSL candidates — a prerequisite for spintronic and quantum device integration.
- Fractionalized phase seen by neutron scattering leaves a clear transport signature, independently validating the phase diagram.
- General route to probe other QSL candidates and atomically thin geometries, directly bridging quantum materials and spintronics.

Technical Approach

- α -RuCl₃ flakes (27–75 nm) interfaced with 3 nm Pt Hall bars via e-beam lithography; transport measured 1.5–18 T, 1.5–300 K
- Angular oscillations of ρ_{xx} and ρ_{xy} fitted to extract SMR amplitude and phase across all magnetic phases
- SMR phase distinguishes longitudinal vs. transverse spin anisotropy, yielding a complete experimental phase diagram



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- **NQISRC Intellectual Role:** *Collaborator*
- **NQISRC Funding Role:** *Minority*
- **Explanation of Funding Institution Contributions**
 - *Quantum Science Center (QSC/NQISRC): Supported theoretical interpretation and quantum materials research contributions from ORNL and collaborating investigators, particularly in spin anisotropy and quantum spin liquid physics.*
 - *DOE SciDAC Program: Supported computational and theoretical efforts related to spin dynamics and advanced scientific computing.*
 - *Tohoku University / AIMR / MEXT / JSPS: Led experimental device development, measurements, and primary materials characterization.*
 - *NSF & University Collaborators: Supported crystal growth, magnetic characterization, and complementary experimental analysis.*

