Oral Session D2 (Friday, February 16)

Chair: Evgeny Y. Tsymbal , University of Nebraska-Lincoln (UNL)

Keynote Talk

11 : 00 - 11 : 40

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Altermagnets: An unconventional magnetic class

Conventional magnets can be divided in two basic classes – ferromagnets and anti-ferromagnets. In the first part of the talk, we will recall that the ferromagnetic order offers a range of phenomena for energy efficient IT, while the vanishing net magneti-zation in antiferromagnets opens a possibility of combining ultra-high energy efficiency, capacity and speed of future IT [1-4]. In the main part of the talk we will move on to our recent predictions of instances of strong time-reversal symmetry breaking and spin splitting in electronic bands, typical of ferromagnetism, in crystals with antiparallel com-pensated magnetic order, typical of antiferromagnetism [5-8]. We resolved this apparent fundamental conflict in magnetism by symmetry considerations that allowed us to classify and describe a third basic magnetic class [6,7]. Its alternating spin polarizations in both crystal-structure real space and electronic-structure momentum space suggested a term altermagnetism. A *d*-wave spin-polarization order in altermagnets is a direct counterpart of the unconventional d-wave superconducting order in cuprates. We will discuss predic-tions and initial experimental verifications [9,10] in which altermagnets combine merits of ferromagnets and antiferromagnets, that were regarded as principally incompatible, and have merits unparalleled in either of the two conventional magnetic classes. We will introduce the broad materials landscape of altermagnetism and show how its unconven-tional nature enriches fundamental concepts in condensed matter physics, such as the Kramers theorem [10]. We will show that this underpins a development of a new avenue in spintronics, elusive within the two conventional magnetic classes, based on strong and conserving spin phenomena, without magnetization imposed scalability limitations.

References

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11 : 40 - 12 : 00

Symmetry of emergent physical phenomena free from relativistic spin-orbit coupling

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This study explores spin-order-driven phenomena, especially in systems with light magnetic atoms, revealing unique physical properties linked to the spin degree of freedom. Our approach, which decouples spin and orbital degrees of freedom, offers a deeper understanding of the relationship between spin structure dimensionality and physical properties arising from the spin order. Unlike traditional magnetic space group symmetry analyses, the spin crystallographic group exhibits richer symmetries including spin translation symmetry. We discuss the geometrical nature of the anomalous Hall effect and magnetoelectric effect arising from nonrelativistic spin-charge coupling. This method serves as a systematic tool for exploring significant electromagnetic responses rooted in spin order. Overall, our work advances the understanding of spin-driven phenomena, paving the way for realizing giant responses associated with the spin degree of freedom in various magnetic materials.

12 : 00 -12: 20

Acoustically driven magnon-phonon coupling in a layered antiferromagnet

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Contributed Oral

Harnessing the causal relationships between mechanical and magnetic properties of Van der Waals materials presents a wealth of untapped opportunity for scientific and technological advancement, from precision sensing to novel memories. This can, however, only be exploited if the means exist to efficiently interface with the magnetoelastic interaction. Here, we demonstrate acoustically driven spin-wave resonance in a crystalline antiferromagnet, chromium trichloride, via surface acoustic wave irradiation. The resulting magnon-phonon coupling is found to depend strongly on sample temperature and external magnetic field orientation, and displays a high sensitivity to extremely weak magnetic anisotropy fields in the few mT range. Our work demonstrates a natural pairing between power-efficient strainwave technology and the excellent mechanical properties of Van der Waals materials, representing a foothold toward widespread future adoption of dynamic magnetoacoustics.

References

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12 : 20 - 12 : 40

Emergent isotropic spin fluctuations from a diluted 2D anisotropic antiferromagnet

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A prominent characteristic of two-dimensional magnetic systems is the enhanced spin fluctuations, which reduce the ordering temperature [1]. We have proposed a novel mechanism for obtaining an extreme magnetic response of emergent isotropic spin fluctuations from two-dimensional anisotropic antiferromagnets. Using a diluted antiferromagnet built in the iridate superlattice thin film $[(SrIr_{1-\delta}Ti_{\delta}O_3)/(SrTiO_3)_2]$ (Fig. 1), we have demonstrated that a magnetic field of only 1000th of the spin exchange coupling can increase the crossover (ordering) temperature by 600% [2]. Such an extraordinary magnetic response is enabled because the system directly enters the antiferromagnetically ordered state from the isotropic disordered state, skipping the intermediate anisotropic stage. The underlying mechanism is achieved on the pseudospin-half square lattice realized in the superlattice thin film that is designed to linearly couple the staggered magnetization to external magnetic fields by virtue of the rotational symmetry-preserving Dzyaloshinskii–Moriya interaction. Our model analysis shows that the skipping of the anisotropic regime despite finite anisotropy is due to the characteristic length scale switch under moderate dilution. The demonstrated field-tunable antiferromagnetic ordering temperature is expected to be useful in antiferromagnetic spintronics.

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References

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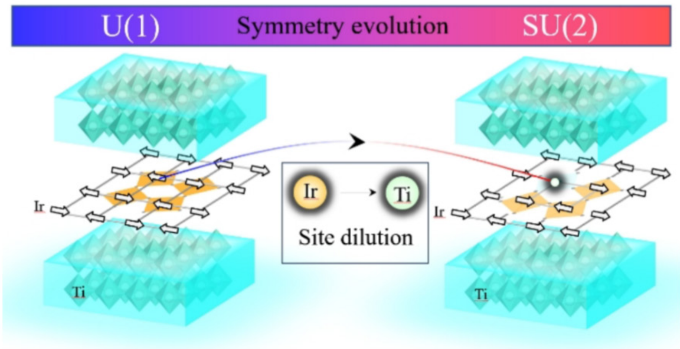

Fig. 1 Symmetry evolution in the magnetic response to external fields upon site dilution.