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Antiferromagnets as Deterministic Mutual Control Multiferroics

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In this talk, we will present a conceptual shift in the design of multiferroics, moving beyond the traditional pursuit of origin-based "Type-II" materials to introduce an instructive classification based on control capacity: coexistence (Type-C) and deterministic mutual control (Type-D). Because a shared microscopic origin in Type-II multiferroics is inherently insufficient to overcome the symmetry constraints that forbid direct linear cross-control, we propose a new theoretical pathway to realize Type-D multiferroics by elevating the antiferromagnetic (AFM) order to a crucial mediator. Utilizing its dual feature of transforming non-trivially under both spin- and real-space symmetries, the AFM order naturally unlocks intrinsic trilinear couplings that rigidly sign-lock entangled ferroic orders. Specifically, breaking rotational or mirror symmetries in altermagnets drives a trilinear magnetoelastic coupling, whereas breaking spatial inversion in conventional AFMs enables direct trilinear magnetoelectric coupling. Building on this trilinear mechanism, we unveil a previously unexplored latent multiferroic (Type-L) phase, demonstrating how external fields can activate deterministic mutual control and yield nontrivial macroscopic responses even from singly-ordered or high-temperature non-ordered parent phases. Ultimately, this symmetry-guided blueprint transforms the vast family of AFMs into a universal platform for designing next-generation deterministic spintronics.