Topological magnetism in 2D materials: from proximity-induced effects to kagomerization

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The discovery of two-dimensional (2D) van der Waals (vdW) magnetic materials and their heterostructures has opened up an exciting platform for investigating emergent phenomena with profound implications for information technology. These materials are currently being explored to uncover non-trivial spin-textures situated at the intersection of magnetism, spintronics, and topology. In this talk, I will discuss our recent first-principles investigations showcasing the creation and the all-electric switching of magnetic skyrmions and antiferromagnetic meronic textures in CrTe2-based heterostructures [1,2,3]. Frustrated Néel merons represent novel topological entities within the domain of topological magnetism, since they arise in a frustrated Néel magnetic environment and manifest as multiple intertwined hexamer textures. Additionally, I will delve into a process termed 'kagomerization', where we generate a two-dimensional kagome lattice within monolayers of transition metals using a hexagonal boron nitride (h-BN) overlayer [4,5]. Traditionally realized in complex multi-atomic bulk compounds, kagome lattices are unexpectedly induced by h-BN, leading to a significant rearrangement of transition metal atoms on an fcc(111) heavy-metal surface. This reconstruction is found to be rather generic, profoundly influencing the underlying magnetic properties and facilitating the stabilization of various topological magnetic solitons, including skyrmions and bimerons. Our findings pave the way for proximity-induced manipulation of both ferromagnetic and elusive antiferromagnetic chiral structures within the same 2D material, holding promise for future information technology devices leveraging quantum materials. Furthermore, our results challenge the conventional view of h-BN solely as a passive capping layer, revealing its potential not only for restructuring the atomic structure of underlying materials (e.g., through magnetic film kagomerization) but also for enabling electronic and magnetic phases critical for the next generation of device technologies.

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References

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