Topological Spin Textures in SnC/MnSeX (X=Se, Te) Heterostructures Enabled by Interface Engineering

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Two-dimensional van der Waals heterostructures provide a powerful platform for tailoring magnetic interactions beyond the limits of pristine monolayers. In this work, we demonstrate that interfacing ferromagnetic MnSeX (X = Se, Te) monolayers with a nonmagnetic SnC layer leads to a pronounced enhancement of the interfacial Dzyaloshinskii–Moriya interaction (DMI), driven by inversion symmetry breaking and strong spin–orbit coupling [1]. Using first-principles density functional theory combined with atomistic spin simulations, we systematically investigate the electronic structure, magnetic anisotropy, finite-temperature magnetism, and chiral spin textures of SnC/MnSeX heterobilayers.

Our results reveal that the SnC/$MnSe_2$ heterostructure exhibits half-metallic behavior with a substantially enhanced Curie temperature compared to the isolated $MnSe_2$ monolayer, while Janus-based SnC/MnSeTe and SnC/MnTeSe heterostructures display metallic character and tunable magnetic anisotropy. Remarkably large interfacial DMI values, comparable to those of prototypical skyrmion-hosting systems such as Co/Pt [2] and Fe/Ir [3], are obtained, enabling the stabilization of Néel-type skyrmions. Phase diagrams constructed as a function of temperature and external magnetic field reveal multiple topological regimes, including spin spirals, skyrmion lattices, isolated skyrmions, and uniform ferromagnetic states.

Furthermore, we show that external electric fields provide an additional degree of control over exchange interactions, magnetic anisotropy, and skyrmion stability without significantly altering skyrmion size. These findings highlight interface engineering in SnC/MnSeX heterostructures as an effective route toward electrically tunable chiral magnetism, offering promising prospects for next-generation two-dimensional spintronic and topological memory devices.

References

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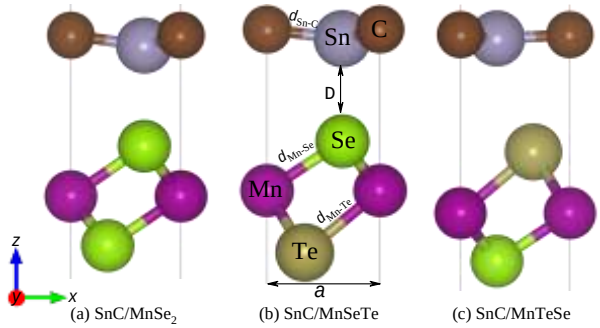

Figure 1: Side views of the (a) SnC/$MnSe_2$, (b) SnC/MnSeTe, and (c) SnC/MnTeSe heterobilayers.

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