

Condensed Matter Physics Seminar Series

3D Magnetic Textures with Mixed Topology

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Magnetic materials can host complex spin textures stabilized by the interplay of competing interactions. When these textures are topologically protected, they gain robustness against perturbations. In this talk, I will introduce a range of such configurations, including spin spirals, vortices, skyrmions, hopfions, and recently discovered screw dislocation defects [1], and explain their stability from a topological perspective. In 3-dimensional systems, topology plays a richer role, enabling knotted and linked structures like hopfions [2] that are characterised by an integer Hopf index H . Recently, we showed that metastable hopfions can also arise in a new class of magnetic models, termed screw chiral magnets, where symmetry-transformed interactions stabilize nontrivial three-dimensional textures in a ferromagnetic background [3]. However, traditional classifications using homotopy groups fall short when magnetic textures form in non-uniform backgrounds. I will present a new framework [4] based on flux tubes of emergent magnetic field, and their linking numbers, culminating in an analytical formula for the Hopf index H as a flux-weighted average of

these linking numbers. This approach not only enables efficient computation of H in finite systems, avoiding the difficulties associated with numerical evaluation of the Whitehead integral [5], but also reveals that non-integer or continuously varying H can emerge in "mixed topology" states. Such textures interpolate between distinct topological sectors, providing new insight into the topology and tunability of magnetic textures.

References

- [1] M. Azhar et al., Phys. Rev. Lett., 2022, 128, 157204.
- [2] Faddeev, L., Niemi, Nature, 1997, 387, 58–61; P. Sutcliffe, Phys. Rev. Lett., 2017, 118, 247203.
- [3] S. Shaju, M. Azhar, K. Everschor-Sitte, APL Mater., 2026, 14, 051111
- [4] M. Azhar et al., 2026 SciPost Phys. 21, 023.
- [5] R. Knapman, M. Azhar, et al., Phys. Rev. B., 2024, 111, 134408.

Tuesday, October 6th at 9am
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