

# Computational Science Alliance Overseas Dispatch Report

The University of Tokyo, School of Engineering, Department of Applied Physics, Motome group

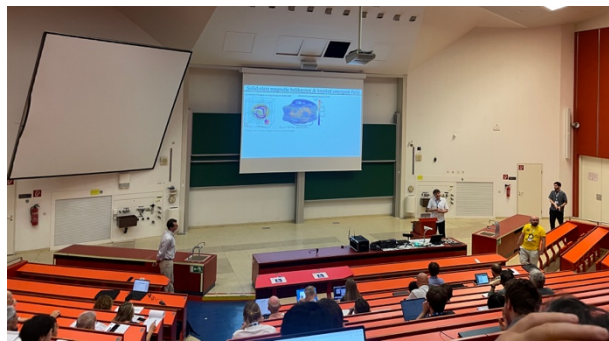
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Place:

- Max Planck Institute for Solid State Research, Stuttgart Germany
- 3DMAG 2026, Technical University Wien, Vienna, Austria

Period: July 6<sup>th</sup>-17<sup>th</sup> 2026

With the support of the Computational Science Alliance Overseas Dispatch Program, I visited the Max Planck Institute for Solid State Research (MPI-FKF) in Stuttgart, Germany, and attended the 1st International Symposium on Three-Dimensional Nanomagnetism (3DMAG 2026), held at TU Wien in Vienna, Austria.



During my visit to MPI-FKF, a research institute specializing on condensed matter physics and materials science, I was hosted by Dr. Andreas Schnyder of the Department of Quantum Many-Body Theory. I held a seminar titled “Thermodynamic stability and magnetoelectric response of emergent magnetic monopoles in topological magnets”.

The first part of the seminar addressed the stabilization properties of hedgehog lattices (HLs), which are periodically aligned three-dimensional (3D) spin textures hosting emergent magnetic monopoles, for different interaction ranges. Existing theoretical models often treat insulating and metallic systems separately, representing them in terms of short-range and effectively long-range interactions, respectively. In this study, these limits were interpolated by introducing a spatial exponential decay in the interaction. Monte Carlo simulation showed that HLs can be stabilized over a broad range of interaction lengths. A quantitative characterization of the associated phase transitions requires finite-size scaling based on sufficiently large 3D systems, together with efficient configuration sampling. Advanced computational approaches are therefore indispensable for this research.

The second part of the seminar examined the magnetoelectric (ME) response of HLs for model parameters corresponding to insulating systems, to examine methods to detect 3D topological spin textures as a counterpart of the topological Hall effect. Within this model, the ME response was found to provide a sensitive probe for HLs. In particular, the spin-induced macroscopic polarization reflected the microscopic configuration of skyrmion strings

connecting hedgehogs and antihedgehogs. Moreover, the dielectric constant exhibited anomalies at the topological transition between distinct HL phases.

Following the seminar, I discussed my work with Dr. Schnyder and other members of the department. Their questions and feedback provided valuable perspectives on the nature of topological protection in topological spin textures.

The following week, I attended 3DMAG 2026 at TU Wien. During a two-hour poster session, I presented my current research on the same topic as the seminar. The session gave me an opportunity to explain my work to researchers from both theoretical and experimental backgrounds.

The conference presentations covered emerging topics such as double-helix magnetic nanostructures, Bloch points, magnetic hopfions, and the effects of curvature and geometry on magnetic behavior. They gave me a clearer understanding of current experimental capabilities, major research questions, and the development of the research community in this field.

A thought-provoking presentation was given by Prof. Claire Donnelly, who discussed how 3D curvilinear geometries can be used to tailor the energy landscape of topological defects, including Bloch points, and to control their dynamics. This prompted me to consider whether curvilinear geometries could be incorporated into large-scale micromagnetic simulations and whether concrete geometrical contributions can be described theoretically for the stability and dynamics of magnetic hedgehogs.

I also spoke to Dr. Alexander Edström about research on flexomagnetic effects in two-dimensional magnets, which showed that curvature can induce magnetization. This discussion led me to consider whether curvature could be exploited to create and stabilize topological spin textures, particularly because it can generate effective interactions such as the Dzyaloshinskii–Moriya interaction and modify spin–orbit coupling.

I would like to express my sincere gratitude to the Computational Science Alliance for its generous support. This program made it possible for me to broaden my scientific perspective, strengthen my international network, and identify new directions for my research.