# Data-driven Multiscale Hysteresis Simulations of Samarium-Cobalt Permanent Magnets

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Due to its superior corrosion resistance under complex chemical environments and outstanding stability at high temperature, samarium-cobalt (Sm-Co) based magnets has promised industries feasibility in various applications. However, the microstructure of such permanent magnets has been unveiled in a sophisticated multiscale fashion, in which most of the primary mechanisms attributing to the magnetic behavior occur on the nanoscale [1]. An enormous gap exists between microstructural characteristics, e.g., the grain size of several 10 to 100 μm compared to Sm-Co's exchange length of 2 nm. In this regard, models on a single scale, such as macroscopic phenomenological models or nanoscale physics-rooted micromagnetics, are insufficient to recapture the hysteresis behavior of the material. The multiscale scenario is thereby a critical path to the reliable prediction of magnetic properties and microstructure-based tailoring of such magnets.

In this work, we perform batched parallel micromagnetic simulations on distinct parameterized nanostructures [2], [3]. Sequentially, the Neural Network (NN) model is trained based on the micromagnetic simulation results to surrogate the local magnetization switching. In particular, this NN model regards the orientation-dependent local magnetization reversal behavior on the mesoscale to a list of internal features on the nanoscale. Finally, the trained model, which stems from micromagnetics but is computationally more efficient and accessible, is applied in the computational homogenization of the magnetic hysteresis on a mesoscale structure.

## References

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