WWU MÜNSTER

Aktuelle Fragen der Nanophysik

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Inverse Problems in Micromagnetics

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Micromagnetic simulations are essential tools in developing next-generation sensors and devices. By predicting how magnetic materials behave at the nanoscale, these simulations guide the design of new technologies for data storage, sensors, and electric motors. Traditionally, researchers use these forward simulations to see how a given magnetic material or structure will perform, helping them refine their designs to improve performance.

However, as we aim for increasingly precise and complex magnetic behaviors, we often need to start with a desired outcome—like a specific magnetic field shape or wave behavior—and then work backward to figure out the material design that will achieve it. This approach is known as solving an inverse problem. Solving inverse problems in micromagnetics lets us create materials and devices with very specific magnetic properties, unlocking new possibilities in fields like ultra-efficient computing and high-precision sensing.

These inverse problems can be computationally demanding, especially when dealing with dynamic systems that change over time, like those in magnonics, where magnetic waves can carry information. To make this feasible, we use a mathematical approach called adjoint method. This method allows us to efficiently compute the adjustments needed to reach our target magnetic behaviors without overwhelming computational costs.

To further streamline the process, we employ modern machine learning tools like PyTorch, which can calculate these adjustments automatically. Using techniques similar to those in neural network training, this approach makes it possible to tackle complex magnetic design challenges with greater speed and efficiency. By combining the adjoint method with machine learning, we open up new pathways for designing highly specialized magnetic materials and devices, paving the way for advancements in sensor technology, data processing, and more.