Noise Effects and Spin Waves in Hydrodynamic Spin Lattices

Hydrodynamic Spin Lattices (HSLs) are arrays of droplets distributed across a vibrating fluid bath. As they bounce and produce waves of their own, they are propelled and become what we call “walking droplets.” A lattice of walking droplets produces emergent behavior analogous to particle-wave interactions at the quantum level. The tendency for synchronization and antisynchronization can be simulated with an ordinary differential equation (ODE) across customizable lattice shapes, sizes, and conditions. Topological defects, or excitations that resist perturbations, are of particular interest, manifesting as solitons in one and two dimensions and as vortices in two dimensions. We make use of the similarities between the HSL model and the established Ising and XY models to classify a phase transition in our model. Phase transitions are changes from ordered states to disordered states with increasing temperature, so we introduce a temperature-like noise term into our ODE to evaluate the grounds for such a comparison. Our second investigation is inspired by applications in magnon spintronics, where we explore the versatility of solitons as non-heat-dissipating signal carriers by constructing logic gates. We ultimately aim to understand the patterns of synchronization in the HSL model and demonstrate the utility of its mechanics for information flow.