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Tunable domain-wall dynamics in multi-domain spin structures in an ultracold 87Rb gas

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We study domain wall motion in pseudo-spin-½ ultracold ^{87}Rb gas initialized in an 'up-down-up'configuration, with helical domain walls between the regions of different magnetization. The interplay between diffusive pressure and induced spin-currents due to spin-exchange collisions leads to complex domain-wall dynamics. We qualitatively distinguish two regimes of wall motion. At short times, transverse spin is confined to the domain walls, slowing down domain wall dynamics via exchange collisions. Later, coherence in the domain wall decreases, and the velocity of the wall increases. We demonstrate that spontaneous domain-wall motion may be tuned through altering the initial domain orientation and coherence in the domain wall and have modeled the observed wall trajectories with numerical solutions of a quantum Boltzmann equation. We also use simulations of the quantum Boltzmann equation to train a neural network to predict initial conditions that lead to specific target domain wall trajectories. Achievable spontaneous domain wall trajectories are limited by the restricted phase space of initial parameters; however, optically applying effective magnetic field gradients alters spin currents through the domain wall and offers the possibility of dynamic control of wall motion. We present progress toward this goal using machine-learning techniques to predict time-varying effective magnetic field gradients as control parameters.

Keyword-1

Spinor gas

Keyword-2

Spin transport

Keyword-3

Out-of-equilibrium Bose gas

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