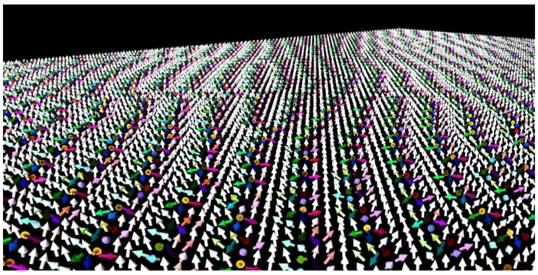

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Skyrmion stacking in stray field-coupled ultrathin ferromagnetic multilayers

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We explore the energy landscape of ferromagnetic multilayer heterostructures that feature magnetic skyrmions in each magnetic layer. Such magnetic heterostructures have been recently pursued as possible hosts of room temperature stable magnetic skyrmions suitable for the next generation of low power information technologies and unconventional computing. The presence of stacked skyrmions in the adjacent layers gives rise to a strongly coupled nonlinear system, whereby the induced magnetic field plays a crucial stabilizing role. Starting with the micromagnetic modeling framework, we derive a general reduced energy functional for a fixed number of ultrathin ferromagnetic layers with perpendicular magnetocrystalline anisotropy. We next investigate this energy functional in the regime in which the energy is dominated by the intralayer exchange interaction and formally obtain a finite-dimensional description governed by the energy of a system of one skyrmion per layer as a function of the position, radius and the rotation angle of each of theses skyrmions. For the latter, we prove that energy minimizers exist for all fixed skyrmion locations. We then focus on the simplest case of stray field-coupled ferromagnetic bilayers and completely characterize the energy minimizers. We show that the global energy minimizers exist and consist of two stray field-stabilized N\'eel skyrmions with antiparallel in-plane magnetization components.

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