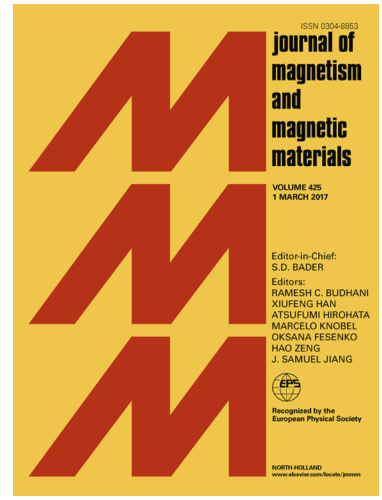

Interaction of isolated skyrmions with point and linear defects

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Interaction of isolated skyrmions with point and linear defects

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Abstract

The dynamic behavior of individual skyrmions is highly affected by the defects in the materials that host them. Here we develop a theory to account for the effect that defects produce over the skyrmion dynamics. The skyrmion-defect interaction mechanism is explained at an atomic level as a local modification of exchange, Dzyaloshinskii-Moriya (DM) and/or anisotropy interaction. Relevant micromagnetic magnitudes as the energy density and effective magnetic fields arising from the presence of the defect are derived. We also find analytical expressions for the forces exerted by this defect over a skyrmion within Thiele's rigid approximation. Both point-defects as well as linear defects are considered.

1. Introduction

Magnetic skyrmions are whirling magnetization structures that, due to their small size (few tens of nanometers), possible high stability and easiness of movement (currents orders of magnitude lower than those needed to move domain walls can move skyrmions) are being considered as highly promising information carriers for a new generation of ultradense magnetic memories and logic devices [1]. From the firsts observations of magnetic skyrmions in the form of hexagonal lattices [2, 3], a large experimental effort is being done to generate and control individual skyrmions [4, 5, 6, 7, 8, 9, 10, 11, 12, 13].

At the *fundamental level*, the magnetic state of a magnetic material depends on the interaction between the spins of the electrons and ions with the local electromagnetic fields present in their environment. The formulation of the adequate relevant Hamiltonian and the resulting energy band structure can describe the system at this level [14]. The conventional interactions in magnetic systems are the exchange interaction described by the Heisenberg hamiltonian, the dipole-dipole interaction, and the magnetocristalline anisotropy [15]. The indirect exchange interaction of two atomic spins through an atom with a strong spin-orbit coupling (SOC) in lattices with lack or breaking of inversion symmetry, or the uncompensated SOC in interlayers between ferromagnetic and metallic films, can also generate a Dzyaloshinskii-Moriya (DM) interaction [16, 17, 1, 18]. This DM interaction is a key ingredient for the formation and stabilization of isolated