Giant Skyrmion and Skyrmion Burst in Thin Ferromagnetic Films

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In this work we investigate topological solitons in thin ferromagnetic films. First, we propose a new mechanism of skyrmion materialization on the basis of the competition between the magnetic dipole-dipole interaction (DDI) and the Zeeman interaction. DDIs turn a ferromagnet into a frustrated spin system, which allows a nontrivial spin texture such as a giant skyrmion ($\sim 1\mu$m) for typical sample parameters. We derive an analytic formula for the skyrmion radius. A giant skyrmion is shown to collapse into a singular point by emitting spin waves (skyrmion burst), when external mangetic field is increased beyond the critical one. A giant skyrmion may well be the magnetic domain already found in a TbFeCo thin film. We also study topological excitations in chiral ferromagnetic thin films such as MnSi and FeCoSi, where the Dzyaloshinskii-Moriya interaction (DMI) dominates the DDI at short distance ($\sim$ 40nm). At finite temperature, topological excitations emerge by the competition between the DMI and the Zeeman effect. They are compact skyrmions, merons and bimerons. A distinguished feature is that the topological charge density is strictly confined within compact domains. We construct a phase diagram in the plane of temperature and magnetic field, which is comprised of the helix, meron, skyrmion-crystal, skyrmion-gas and ferromagnet phases.

M. Ezawa, Phys. Rev. Lett. 105, 197202 (2010): Phys. Rev. B 83, 100408(R) (2011):
cond-mat/arXiv:1102.0635.