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Chiral Magnetism: A Geometric Perspective[1]

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Chiral ferromagnets have spatially modulated magnetic order exemplified by helices, spirals, and more complex patterns such as skyrmion crystals. The theoretical understanding of these states is based on a competition of a strong Heisenberg exchange interaction favoring uniform magnetization and a weaker Dzyaloshinskii-Moriya interaction promoting twists in magnetization. We offer a geometric approach, in which chiral forces are a manifestation of curvature in spin parallel transport [1]. The resulting theory is a gauged version of the Heisenberg model, with the Dzyaloshinskii-Moriya vectors serving as background SO(3) gauge fields. This geometrization of chiral magnetism is akin to the treatment of gravity in general theory of relativity, where gravitational interactions are reduced to a curvature of spacetime. An immediate benefit of this geometrical perspective is a simple way to define a conserved spin current in the presence of spin-orbit interaction. We show that the ground state of the gauged Heisenberg model in 2 spatial dimensions is a hexagonal skyrmion crystal in a wide range of applied magnetic fields. The simplicity of the model allows for an efficient analytical treatment of this problem using standard field-theoretic methods. Monte Carlo simulations confirm our analytical arguments. [1] D. Hill, V. Slastikov, and O. Tchernyshyov, arXiv:2008.08681.

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