Study of the phase diagram of chiral magnets by nonlinear magnetic responses

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2 de febrero de 2018

Aula 3, Edificio A, Facultad de Ciencias

(frente al CEQMA)

12:30 h

Ac magnetic responses are classified into characteristic five types from the phenomenological viewpoints. The enormous third-harmonic response observed in chiral crystals is physically equivalent to nonlinear phenomenon seen in the Duffing equation, which appears in nonlinear spring model. Thus, the magnetic nonlinearity is evaluated with the magnitude of the third-harmonic magnetic response. For reference, the spin-glass system also presents the third-harmonic magnetic response, whereas the magnitude against the first-order one is at most a few percent. Some chiral magnets, however, exhibit enormous third-harmonic response, whose magnitude against the first-order one is over ten percent. By using this diagnostics approach, we discuss the robustness of **nonlinear spin texture** consisting of **topological objects** such as kinks and vortices.

$Cr_{1/3}NbS_2$ is a typical mono-axial chiral magnet with one kind of Dzyaloshinskii-Moriya (DM) vector. By applying dc magnetic field perpendicularly to the chiral helical axis, a magnetic supperlattice termed chiral soliton lattice (CSL) appears, finally leading to the forced-ferromagnetic state. CSL is the spin solitonic texture consisting of both kinks (solitons) and ferromagnetic arrays, so that it exhibits the discrete magnetization against the magnetic field scanning.

MnSi is the chiral magnet with three DM vectors. At zero magnetic field, the multi-domain type of helimagnetic structure is formed. By applying dc magnetic field, the spin solitonic texture, termed the skyrmion lattice (SkL), consisting vortices is stabilized near magnetic ordering temperature.

As for both crystals, the phase diagram as a function of temperature and dc magnetic field is studied by Ac magnetic susceptibility including higher-order harmonic components. In particular, the robustness of nonlinear spin textures such as CSL in $Cr_{1/3}NbS_2$ and SkL in MnSi are discussed via the third-harmonic response.

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