Micromagnetic simulation of MFM tip hysteresis and stray field

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The stray field of MFM tips can be strong enough to compromise the characterization of soft-magnetic materials based nanostructures. On the other hand, this stray-field can be used to alter the magnetic state of the system, getting involved in magnetization reversal of magnetic nanoparticles[1],[2], as well as being used to modify the domain walls, dragging or pushing them away [3],[4],[5] in order to interact with the nanostructured system.

In this work, micromagnetic simulations of a generic MFM tip and its stray field have been performed using MAGPAR in order to obtain, not only the tip-to-sample interaction magnitude[7], but all the three components of the stray-field as a function of the retrace height. This allows us to fit the tip stray-field in terms of simple monopole, dipole and second order multipole expansion, as well as to determine each applicability height range.

We have simulated the complete hysteresis loop of the MFM tip in order to obtain the remanence state and to explore de different states of the tip under external field applied parallel to the Z axis.

Finally, we can appraise the effects of the tip-sample interaction in CoSi and CoZr based thin films systems, which are in good agreement with MFM measurements.

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Figures:

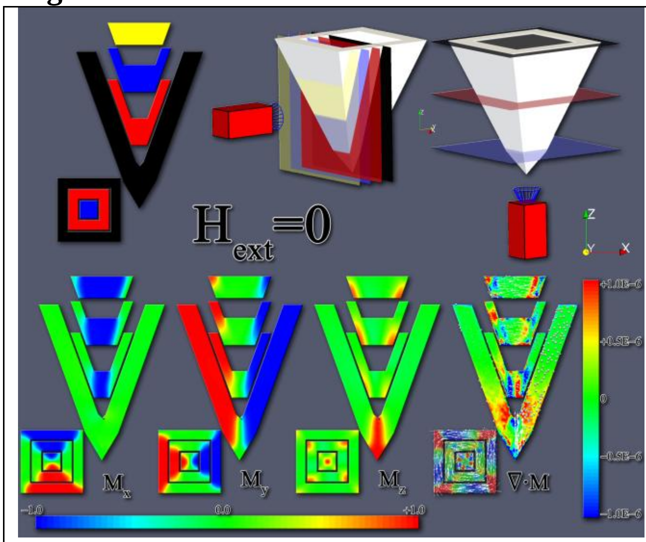

Fig 1: Slices of the MFM-tip model showing the magnetization configuration at remanence state.

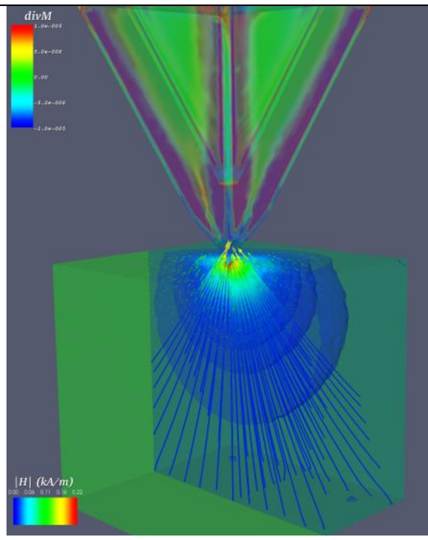

Fig 2: MFM tip magnetic poles distribution and associated stray field.

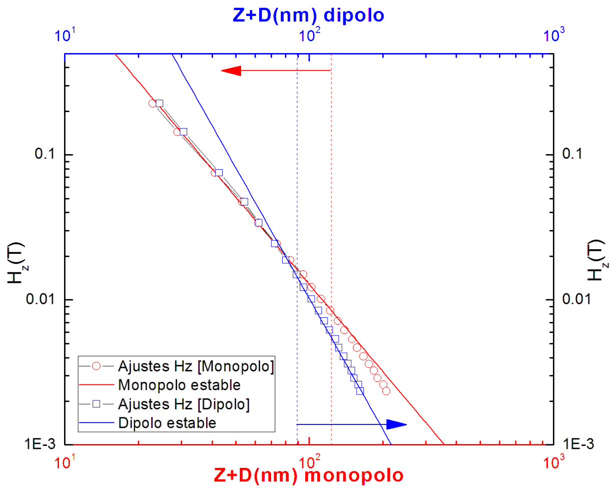

Fig 3: Applicability height ranges for the monopole and dipole fittings.

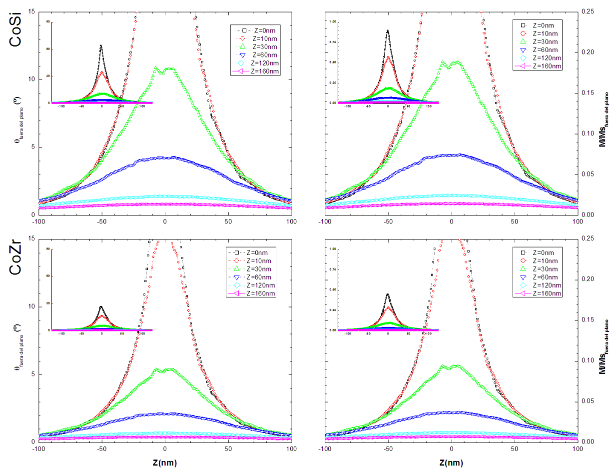

Fig 4: Magnetization *off-plane* displacement due tip-sample interaction in CoSi and CoZr thin films according the simulated H_{tip}.