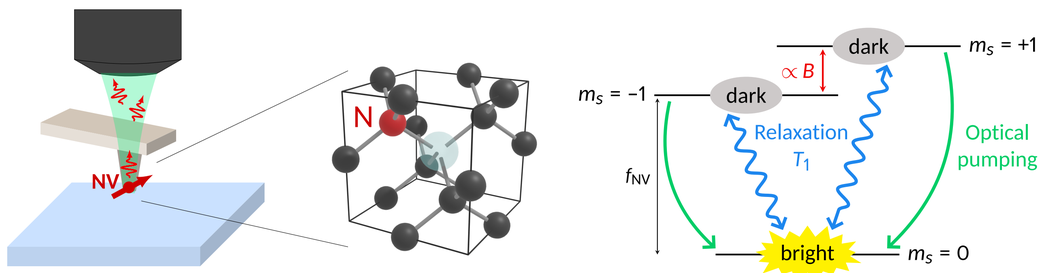
Probing the Internal Texture of Domain walls and Skyrmions through Spin Waves with a Quantum Sensor

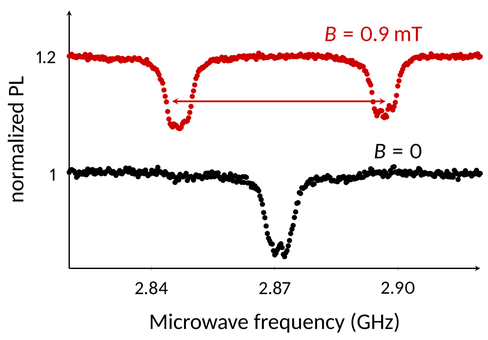
Aurore Finco[1], Pawan Kumar[1], Van Tuong Pham[2], Joseba Urrestarazu[2], Maxime Rollo[1], Olivier Boulle[2], Joo-Von Kim [3], Vincent Jacques [1]

[1]Laboratoire Charles Coulomb, Université de Montpellier and CNRS, Montpellier, France
[2]Université Grenoble Alpes, CEA, CNRS, Grenoble INP, IRIG-SPINTEC, Grenoble, France
[3]Centre de Nanosciences et de Nanotechnologies, CNRS, Université Paris-Saclay, Palaiseau, France

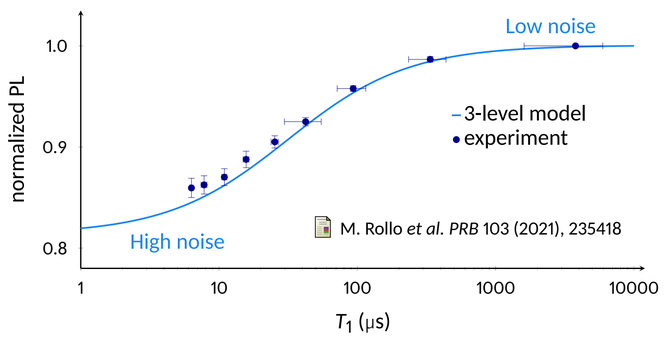
Principle of the measurement



Optically Detected Magnetic Resonance
→ *Measure B*



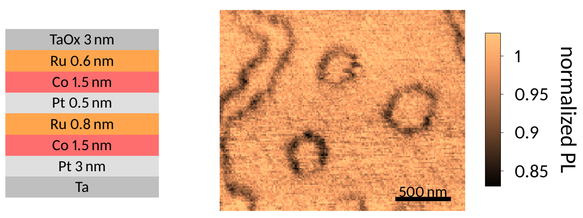
Optical detection of accelerated relaxation
→ *Detect variations of $S_B(f_{NV})$*



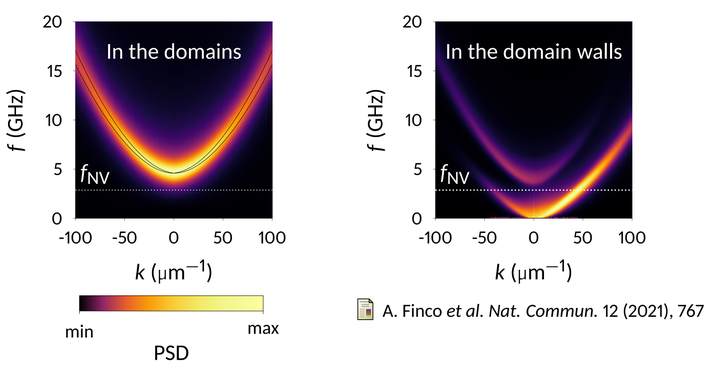
Main results

- We can determine the chirality of Néel domain walls from the intensity of the detected magnetic noise.
- We can determine if skyrmions are of Bloch or Néel type from the magnetic noise pattern along their contour.
- We can determine the chirality of Néel skyrmions from the intensity of the detected magnetic noise.

Relaxometry imaging on a synthetic antiferromagnet



Calculated spin wave dispersion



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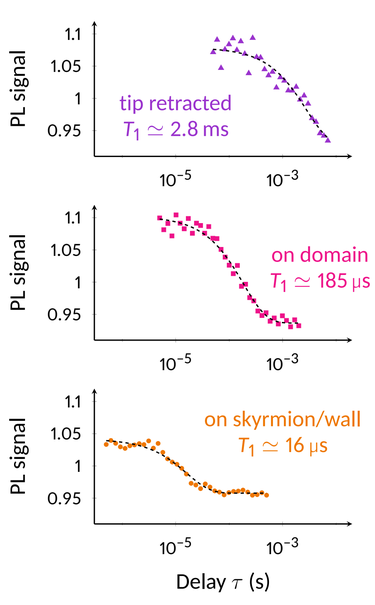
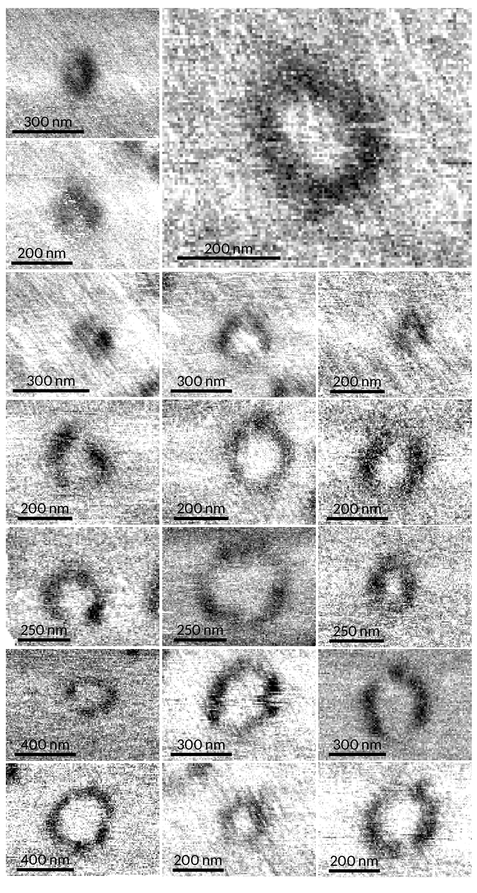


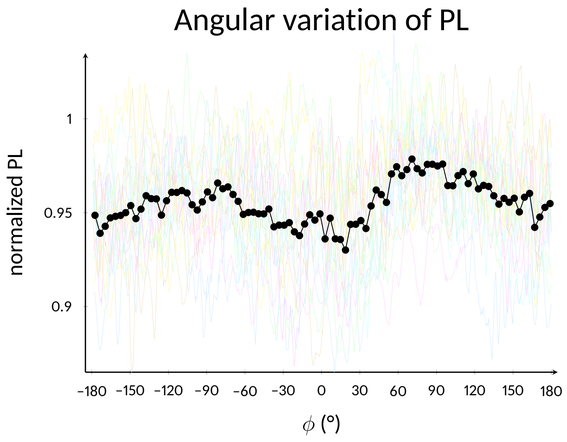
The optical contrast results from an **acceleration of the NV spin relaxation** caused by **spin waves confined in the walls** with frequency matching the NV center resonance. Such spin waves are hardly present in the domains because of the gap.

Analysis of the skyrmion contour

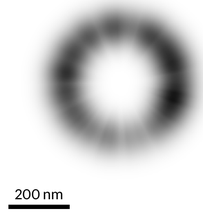
Néel left skyrmions



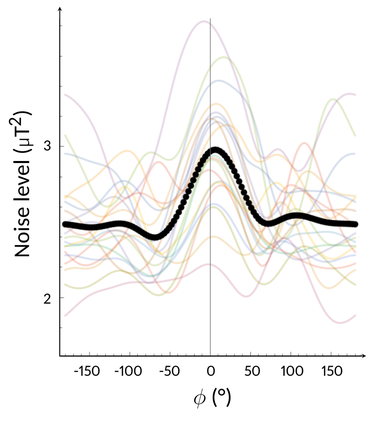
Angular variation of PL



Pattern corresponding to the mean experimental noise profile along the contour



Calculation of the expected noise level, (statistics over anisotropy disorder)



Signal from domain walls

Initial stack

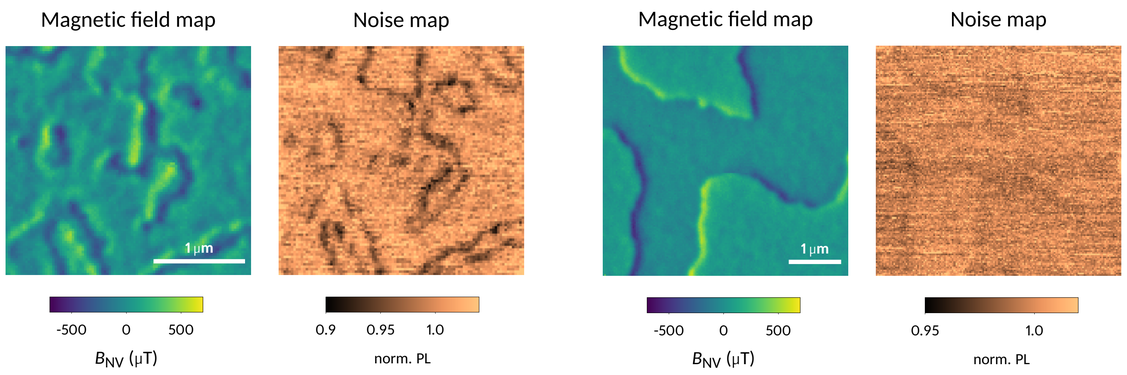
TaOx 3 nm
Ru 0.6 nm
Co 1.5 nm
Pt 0.5 nm
Ru 0.8 nm
Co 1.5 nm
Pt 3 nm
Ta

Néel left walls

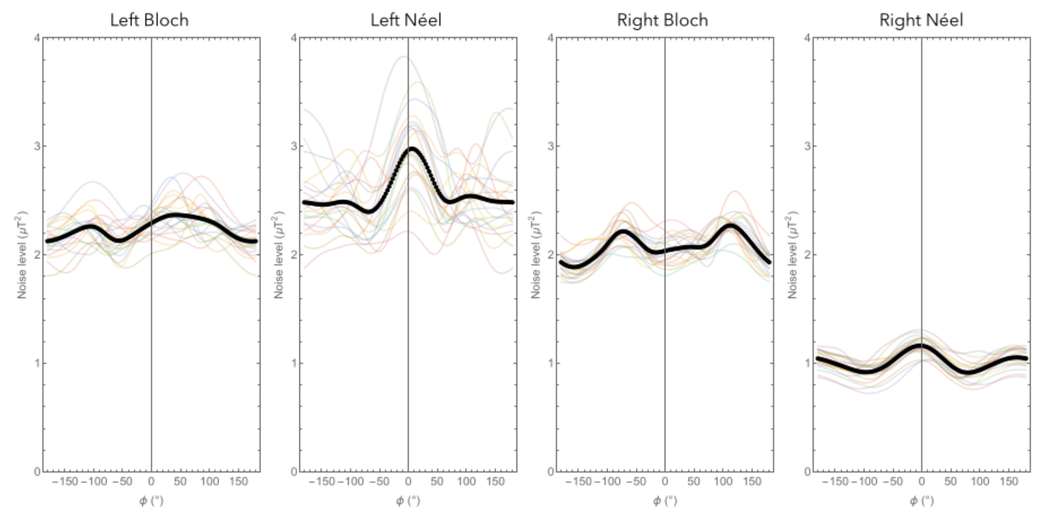
Inverted stack

TEM memb. 20 nm
Ta 3 nm
Pt 3 nm
Co 1.54 nm
Ru 0.85 nm
Pt 0.45 nm
Co 1.54 nm
Ru 0.6 nm
Ta 1.5 nm

Néel right walls



The chirality (left or right) of the Néel wall can be determined from the **intensity of the detected magnetic noise**, which can hardly be done from the stray field maps.



The type of skyrmions (Bloch/Néel) can be determined from the **spatial distribution of the detected magnetic noise**, and the chirality of Néel skyrmions significantly modifies the **noise intensity**.