Abstract:
In the last decade, magnetic ratchet effect of domain walls has been proposed by several groups as a working principle for spintronic devices like magnetic disk storage or shift registers. Indeed, some of the proposed strategies are promising for spintronic devices. In this perspective, we review recent advances in experimental and theoretical aspects of magnetic domain wall ratchet: (a) Fabrication of magnetic field, (b) Kinked domain wall propagation, (c) Magnetic characterization of Kerr effect and XPEEM, (d) Domain wall morphology and pinning, (e) Current induced DW propagation.

Sample fabrication:
Amorphous Co-Si - an (200) substrates
Co and Si are patterned on 30 nm film
Wide defined uniaxial anisotropy
In-plane magnetization easy axis
Kerr microscopy
Relaxation of the film magnetization by propagation of Néel-type walls
Arrays of triangle-shaped holes by electron beam lithography (EBL)
Total area covered: 60 μm wide square with two 10 μm wide trenches
Arrays parallel and at 20° from DA
The base and height of the triangle: h = 600 nm and 1 μm
Columns (b and h) separation: multiples of 3
h = nb and h = nm with m and n = 1, 2, 4, 5.

Magnetic characterization: Kerr microscopy
Wide field Kerr effect microscopy from Euco Magnetics GmbH, operating in longitudinal configuration.
Magnetic field in plane and parallel to the base of the triangle.
Live videos of theDW propagation while changing the applied magnetic field.

Magnetic characterization: X-ray PhotoEmission Electron Microscopy
XPEEM at the ELETTRA/LABOS XPS beamline of the BessoF facility in Carbonia, (200) substrates.
Key Magnetic Circular Dichroism at Co-Cu edge
3D-resolution
Red-white-blue signal proportional to the projection of the magnetisation along the direction of the incident x-ray beam
Magnetic sample holder (magnetic field during measurements).

Kinked domain propagation (Kerr Microscopy)
Kinks nucleate and propagate when samples are produced at DA from EA.
Kinks produce a 2b movement of the DW while flat walls produce a movement of the DW.

Domain wall morphology and pinning
DW morphology is determined by the interplay between two different asymmetric factors:
- Elastic DW bending under the effect of the applied field pressure, that reflects the asymmetry in the patterned triangular hole shape.
- Half vortex propagation along the edges of the triangular holes.

Current induced DW propagation: Micromagnetic simulations
Starting at a zero magnetization state with a Néel DW located in the middle of the array and then ramping electrical current.
A clear asymmetry is observed in the DW propagation.
Electrical Ratchet effect turned to the magnetic Ratchet
Possible new route for the control of DWs in two opposite directions, each one with a different driving force.

Highlights:
- Ratchet and crossed-ratchet effects in magnetic domain wall motion through 2D arrays of asymmetric submicrometric holes have been achieved.
- Micromagnetic simulations and high-resolution magnetic imaging show that in the submicrometric size regime domain walls become stiff, influencing their propagation.
- Simulations predict the control of an asymmetric propagation of domain walls in two opposite directions with electrical currents and magnetic fields.