153

Locomotion of magnetic surface walkers by rotating and gradient magnetic fields

Author: Jiajun LEI[1]

Co-author: Pavel Kuzhir [2]

[1] *INPHYNI*

[2] *University Côte d'Azur, Institute of Physics of Nice*

Magnetic surface walkers, typically composed of magnetic micro-particles or self-assembled nanoparticle aggregates, exhibit the capability to traverse solid boundaries under the influence of rotating magnetic fields. Their locomotion mechanism resembles that of a wheel rolling on a substrate, with the motion direction dictated by the sense of rotation. Unlike conventional studies that rely on gravity to maintain surface contact, this research employs magnetic field gradients to generate a wall-directed magnetic force. This approach overcomes spatial orientation constraints, thereby broadening the potential applications of such walkers in 3D microfluidic networks, targeted drug delivery, and microrobotics.

During the second year of this doctoral project, research efforts have focused on characterizing the dynamical behavior of self-assembled aggregates under varying magnetic parameters. Systematic experiments conducted in rectangular microchannels at rotation frequencies of 5 Hz, 10 Hz, and 15 Hz demonstrate that increasing the frequency leads to a reduction in aggregate size, while significantly enhancing the translational velocity along the channel walls. Furthermore, the study identifies a complex hydrodynamic coupling effect: in addition to the primary walkers traversing the boundaries, aggregates situated in the bulk region of the channel are induced to move by the localized vortex flow fields generated by the rotating surface walkers. Currently, the investigation is exploring the effects of elliptically polarized rotating magnetic fields on aggregate kinematics, aiming to achieve higher precision in motion control and collective transport efficiency through the optimization of magnetic waveforms.

References

[1] Raboisson-Michel, M., Queiros Campos, …., Kuzhir, P. (2020). Kinetics of field-induced phase separation of a magnetic colloid under rotating magnetic fields. J. Chem. Phys. 153(15) 154902.

[2] Campos, J. Q., Raboisson-Michel, M., Schaub, S., Toe, S., Boulant, L., Verger-Dubois, G., … Kuzhir, P. (2024). Field-induced macroscopic flow of a dilute self-assembling magnetic colloid under rotating magnetic fields. Journal of Fluid Mechanics, 981, A11.

[3] Orlandi, G., Kuzhir, P., et al.. (2016). Microfluidic separation of magnetic nanoparticles on an ordered array of magnetized micropillars. Phys. Rev. E, 93(6), 062604.

Type:

Oral