

## Abstract for GIMC SIMAI YOUNG 2026

# Coupling flutter instability and electromagnetic interactions in a “virtual” micro-robotics experiment

A. Pastore<sup>1</sup>, J. C. Harrop<sup>2</sup>, D. Bigoni<sup>2</sup>, A. Grillo<sup>1</sup>

<sup>1</sup> *Politecnico di Torino/Dipartimento di Scienze Matematiche (DISMA) “G.L. Lagrange”.*  
*Corso Duca degli Abruzzi, 24, Torino TO, Italy*

<sup>2</sup> *Università di Trento/Instability Lab. Via Mesiano, 77, Trento TN, Italy*

*andrea.pastore@polito.it; joel.harrop@unitn.it; davide.bigoni@unitn.it; alfo.grillo@polito.it*

Bio-inspired microrobots are widely investigated as controllable devices for swimming in aqueous environments since their trajectories can be guided via the use of Lorentz-type forces [1]. Yet, the effectiveness of the electromagnetic interaction depends strongly on the locomotion mechanism [2] of the device. At low Reynolds numbers, some propulsion strategies are characterized by flutter instability [3], thereby inducing self-sustained oscillations in certain “rod-shaped” portions of the robots. In this presentation we focus on two “virtual” experiments involving a fluttering microrobot interacting with an ideal solenoid [4]. Our goal is to assess the impact of the electromagnetic interaction on the robot’s fluttering behavior, showing, in the process, how certain effects proper of electromagnetism can be “rediscovered” also in experiments conceived for microrobotics [5]. The design of the robot is inspired by a variant of Ziegler’s double pendulum analyzed in [6].

*Acknowledgements:* Financial support from ERC-ADG-2021-101052956-BEYOND

### References

- [1] Shen, H., Cai, S., Wang, Z., Ge, Z., Yang, W., “Magnetically driven microrobots: Recent progress and future development”, *Materials & Design*, **227**, 111735 (2023).
- [2] Zhang, L., Peyer, K. E., Nelson, B. J., “Artificial bacterial flagella: Fabrication and magnetic control”, *Nano Letters*, **9**, 3663–3667 (2009).
- [3] Dreyfus, R., Baudry, J., Roper, M.L., Fermigier, M., Stone, H.A., Bibette, J.: “Microscopic artificial swimmers”, *Nature*, **437**, 862—865 (2005).
- [4] Pastore, A., Harrop, J.C., Bigoni, D., Grillo, A., “Dynamics of a charged Ziegler’s double pendulum under the joint action of a follower force and Lorentz force”, (2026) *Submitted*.
- [5] Rousseaux, G., Kofman, R., Minazzoli, O., “The Maxwell-Lodge effect: significance of electromagnetic potentials in the classical theory”, *Eur. Phys. J. D*, **49**, 249–256, (2008).
- [6] Cazzolli, A., Dal Corso, F., Bigoni, D., “Non-holonomic constraints inducing flutter instability in structures under conservative loadings”, *J. Mech. Phys. Solids*, **138**, 103919 (2020).