ITI HiFunMat Master Internship Proposal

☒ M 1 ☒ M 2

Title: Out of equilibrium dynamics of soft microparticles

Internship supervisor

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Collaboration with a HiFunMat member (*please indicate their name*)	☐ No ☒ Yes : Stocco Antonio

Student profile looked for

Master program (*more than one box can be ticked)*	☒ Material science and engineering ☒ Chemistry ☒ Physics

Internship description

At low Reynolds numbers, if a force is applied symmetrically in two opposite directions on the center of mass of a rigid object, at the end of the cycle the particle is expected to return to its initial state. More generally, the "scallop theorem" states that a rigid body showing some degrees of freedom cannot gain any net displacement after one cycle of reciprocal body motion when the surrounding fluid is purely viscous.[1] However, some differences are expected when the body is not rigid (and can undergo shape deformation) and when the fluid is not Newtonian. By tuning the frequency and amplitude of an external field in the cycle, an instability (e.g. buckling) or a non-linear effect (e.g. viscoelastic or viscoplastic effects) could be trigged. This may break the symmetry and results in a non-reciprocal body motion showing significant hysteresis. Hence, a shape deformation hysteresis of a soft particle may lead to swimming at low Reynolds numbers.[1]

Self-propulsion under cycles of an external field has recently been reported for microbubbles coated with lipids. Pressure cycles induce asymmetric deformations due to bucking instabilities, which result in the microbubble propulsion at very high speeds, see Figure 1.[2]

In this internship we will study theoretically and experimentally the swimming of soft objects showing hysteresis. For experiments, giant vesicles able be deformed under the effects of electric fields,[3] ultrasounds[4] and shear flows[5] will be investigated.

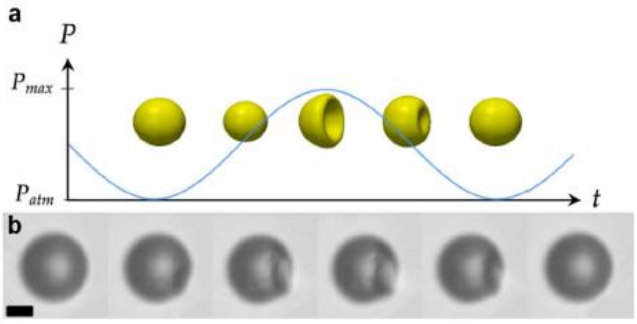

Figure 1. Reproduced from the literature: (a) Simulation results of the buckling of a spherical shell under a pressure cycle resulting in a non-reciprocal body motion. (b) Experimental observation of a buckling transition of a microbubble subjected to a pressure cycle.[2]

1. E. M. Purcell, Am. J. Phys., 1977 **2.** G. Chabouh et al., Commun. Eng., 2023. **3**. M. Aleksanyan et al., Adv. Phys. X, 2023. **4.** P. Marmottant et al., Proc. R. Soc. A Math. Phys. Eng. Sci., 2008. **5**. M. Abkarianet al., Phys. Rev. Lett., 2002.