PhD position in experimental physics:
Self-propelling nematic droplets

Physics of Fluids

The Physics of Fluids group works on a variety of fundamental problems in Fluid Mechanics. Present research areas include turbulence and multiphase flow, micro- and nanofluidics, biomedical flow, granular flow, and fluid-based active matter. The group is active in both fundamental and applied science, the latter often in close collaboration with industrial partners. We set a high priority on a close collaboration of experimental, theoretical, and numerical experts within the group. The group presently has 10 scientific staff members, 7 part-time professors, 4 supporting technicians, and typically 10 postdocs, 40 PhD students, and 10–20 master and bachelor students.

The project (Maass group)

Your research will be on the topic of self-propelled droplets, or active emulsions as model microswimmers. These self-propelled, active agents, or synthetic microswimmers, are a hot topic in experimental fluid dynamics. We can use them as model systems to mimic the behaviour of more complex biological agents like bacteria or algae, controlling and analysing their dynamics from individual swimmers up to emergent collective behaviour. We can also use them to inspire the design of smart materials, acting as collective sensors, delivery agents, even exhibiting primitive, self-organised swarm intelligence. Specifically, active emulsions are a beautiful toy model for nonlinear fluid dynamics [1], while exhibiting a rich set of biomimetic behaviours like different gaits, taxes (i.e. sensitivity to external fields), and complex collective behaviours. These can be tuned by well-controlled parameters like ambient viscosity, fuel activity, state of confinement and chemical composition.

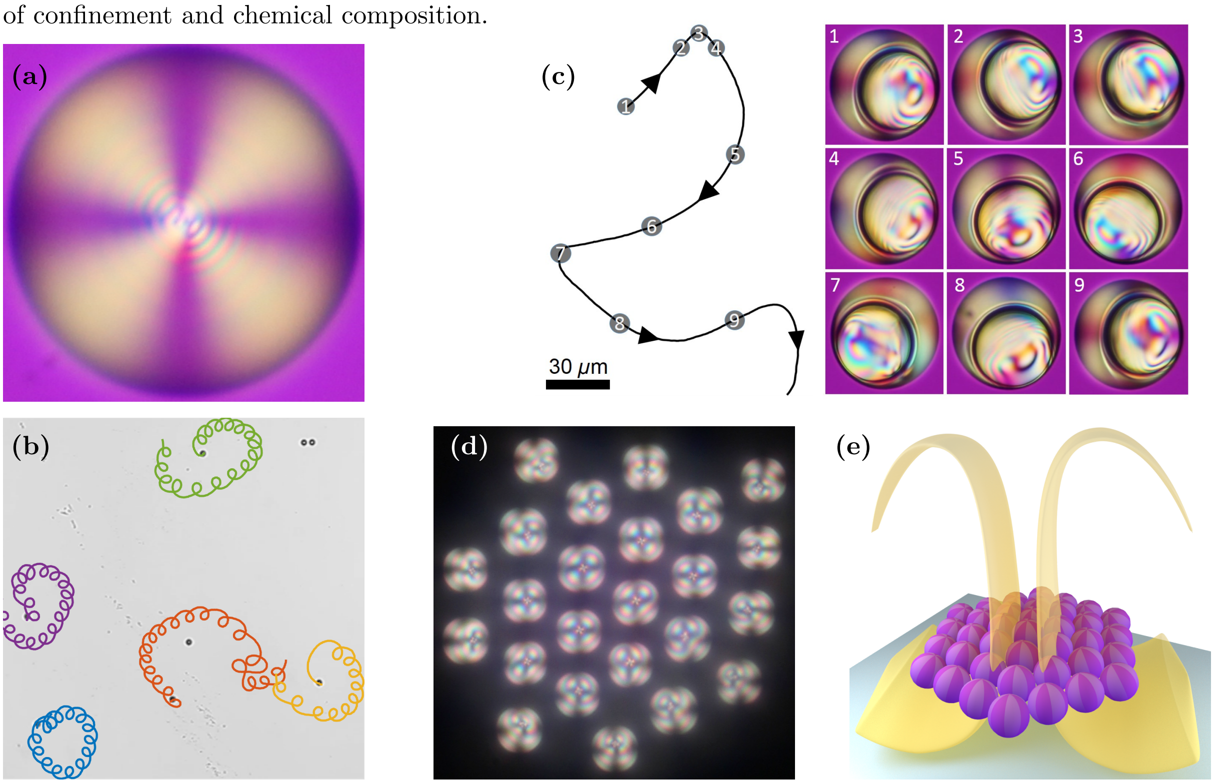

Figure 1: (a) a liquid crystal droplet under polarised microscopy. If the internal symmetry of the liquid crystal is broken, it follows (b) a curling path [3] (tracking data from bright field microscopy). (c) Nematoelastic effects also serve to stabilise water/oil/water multiple emulsions [5]. Multi-droplet ensembles show complex emergent behaviours, e.g. floating 'hovercraft' clusters (d,e) [6,7]

This specific project investigates swimmers [2] based on liquid crystal droplets dissolving in aqueous surfactant solutions [3]. Due to the nematic nature of the oil phase, they exhibit complex oscillatory dynamics [4], and can be functionalised to carry aqueous cores [5] (Figure 1). We will investigate the fundamental control of such single and double emulsion swimmers. The objective is to gain a fundamental understanding on how the interaction of the nematic director field and the chemohydrodynamic self-propulsion inform the swimming dynamics, as well as applications in the functionalisation of aqueous cores in double emulsions, i.e. their use as protocells or cargo carriers.

Our offer

- Leading your own research project in an inspiring and stimulating international work environment.
- Close individual mentorship and a stimulating, collaborative research community with state-of-the-art lab facilities.
- an employment contract for the duration of 4 years, including UT's employee benefits
- a PhD after the successful completion of a 4-year project
- a high-quality personalized educational program
- access to the UT's resources for professional and personal development, and a wide variety of sports and recreation facilities.
- diversity and fairness in hiring.

Your qualification

- a master's degree in physics, mechanical engineering, or a closely related field is required
- fluency in written and spoken English is also required
- experience with microfluidics, microscopy, and image analysis is a plus, as well as previous experience in fluid dynamics of soft matter research.
- so are basic skills in a scripting language like Python or Matlab
- ability to co-supervise MSc and BSc projects and contribute to PoF's teaching activities

Application portfolio

- A motivational letter (1-2 pages max.) describing why you want to apply for this precise position and including how your research interests/experience connect to this position
- A detailed CV
- Academic transcripts from your previous degrees
- Name and e-mail addresses of at least two academic references who are willing to send a letter of recommendation on your behalf
- to be sent via e-mail to c.c.maass@utwente.nl (Corinna Maass, she/her)

An interview with a scientific presentation on your previous work will be part of the interview process.

Literature

1. Michelin, S., Self-Propulsion of Chemically Active Droplets. *Ann. Rev. Fluid Mech.* **55**, 77–101 (2023), arXiv:2204.08953

2. Herminghaus et al., Interfacial mechanisms in active emulsions. *Soft Matter* **10**, 7008–7022 (2014).

3. Peddireddy et al., Solubilization of thermotropic liquid crystal compounds in aqueous surfactant solutions. *Langmuir* **28**, 12426–31 (2012).

4. Krüger et al., Curling Liquid Crystal Microswimmers: A Cascade of Spontaneous Symmetry Breaking. *Phys. Rev. Lett.* **117**, 048003 (2016), arXiv:1605.03396.

5. Hokmabad et al., Topological Stabilization and Dynamics of Self-Propelling Nematic Shells. *Phys. Rev. Lett.* **123**, 178003 (2019), arXiv:1810.07223.

6. Krüger et al., Dimensionality matters in the collective behaviour of active emulsions. *Eur. Phys. J. E* **39**, 64 (2016).

7. Hokmabad et al., Spontaneously rotating clusters of active droplets. *Soft Matter* **18**, 2731–2741 (2022), arXiv:2112.11801.