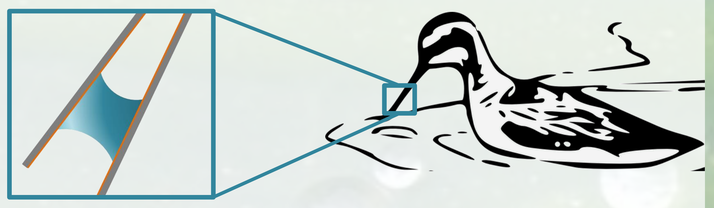
CONTROLLED ACTUATION OF SELF-PROPELLED DROPLETS

Loïc Coudron, Clément Lemenu, Kevin Lemaine, Daniel McCluskey, Christabel Tan, Ian Munro, Arne Erik Holdo, Mark Tracey and Ian Johnston
University of Hertfordshire, School of Engineering and Computer Science, UK

Liquid in a wedge…

Natural occurrence: feeding phalarope shorebird[1]



Theoretical equilibrium: energy based model[2]

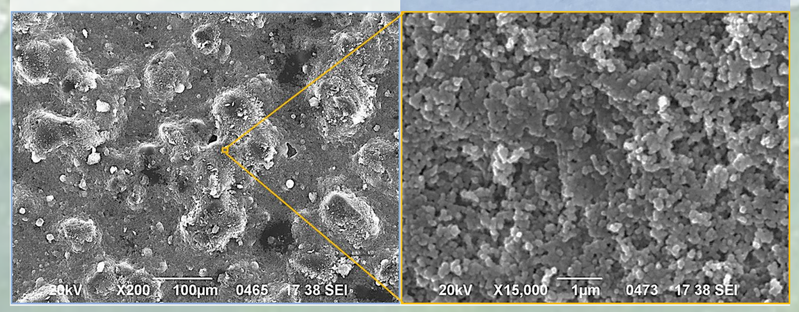
$$U = A_{SL}\gamma_{SL} + A_{LG}\gamma_{LG} + A_{SG}\gamma_{SG}$$
$$= \gamma_{SG}(A_{SL} + A_{SG}) + \gamma_{LG}(A_{LG} - A_{SL}\cos\theta)$$

$$\overrightarrow{F_L} = -\vec{\nabla}U = \gamma_{LG}\left(\cos\theta\frac{dA_{SL}}{dx} - \frac{dA_{LG}}{dx}\right)\cdot\vec{\imath}$$

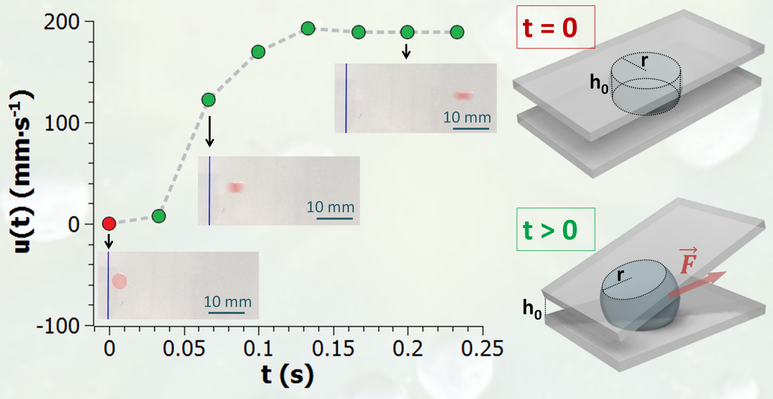
… And superhydrophobic surfaces

Super-non-wetting regime (lotus leaf effect)[3, 4, 5]
- Contact angle $\theta > 150°$
- Cassie-Baxter model[4]

Surface fabrication
Using NeverWet[5] for the present study

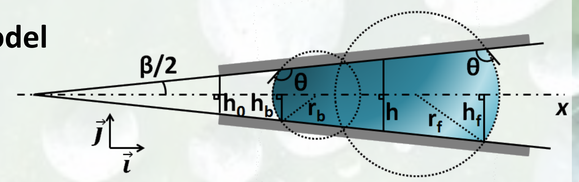


Self-propulsion behaviour…



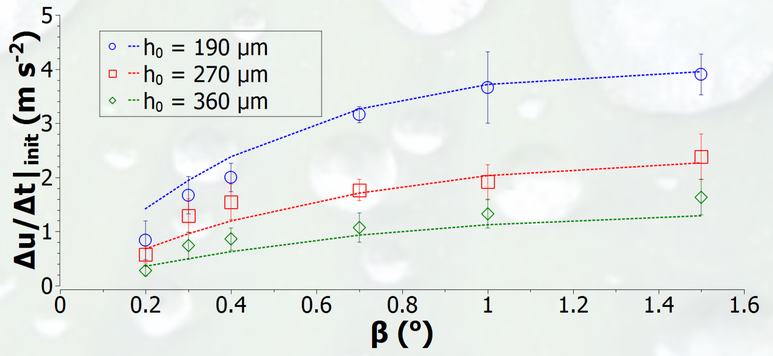
… Tailored by the system geometry

Simplified model
for $0° < \beta < 2°$
$(\cos\beta \approx 1)$

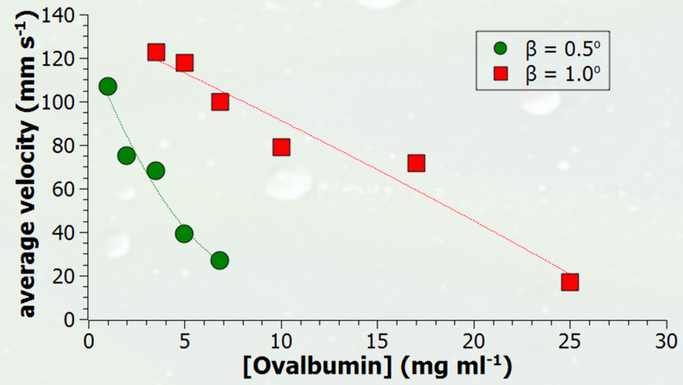


$$\overrightarrow{F_L} = -\gamma_{LG}\left(V\cos\theta\frac{\cot\left(\frac{\beta}{2}\right)}{x^2} + \sqrt{\frac{2\pi}{x}V\tan\left(\frac{\beta}{2}\right)}\right)\cdot\vec{\imath}$$

Acceleration: model (lines) vs experiment (points)



Actuation of protein-laden droplets



Further development potential

- **Droplet generation and transport**
- **Combining self propulsion and electrowetting** for enhanced control over actuation
- **Digital microfluidics using localised deflection** of flexible membranes

Conclusion

Self-propulsion of liquid in non-wetting wedges offers interesting development perspectives for handling biomaterial-laden droplets in lab-on-a-chip devices

References

[1] Prakash, Quéré and Bush (2008) *Science* 320 931-934 **[2]** Ruiz-Gutiérrez, Semprebon, McHale and Ledesma-Aguilar (2018) *J. Fluid Mech.* 842 26-57 **[3]** Ensikat, Ditsche-Kuru, Neinhuis and Barthlott (2011) *Beilstein J. of Nanotech.* 2 152-161 **[4]** Lafuma, and Quéré (2003) *Nature Mater* 2 457–460 **[5]** Latip, Coudron, McDonnell, Johnston, McCluskey, Day and Tracey (2017) *RSC Advances* 7 49633-49648