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Tunable shape oscillations in adaptive droplets

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Soft materials can undergo irreversible shape changes when driven out of equilibrium [1,2]. When shape changes are triggered by processes at the surface, geometry-dependent feedback can arise. Motivated by the mechanochemical feedback observed in multicellular systems [1,3-5], we study incompressible droplets that adjust their interfacial tensions in response to shape-dependent signals. We derive a minimal set of equations governing the mesoscopic droplet states controlled by just two dimensionless feedback parameters. We find that single adaptive droplets display different classes of excitability arising from a Bogdanov-Takens-Cusp bifurcation, and that interacting droplet pairs exhibit symmetry-breaking and tunable shape oscillations ranging from near-sinusoidal to relaxation-type, which stem from a saddle-node pitchfork bifurcation. Our tractable framework provides a paradigm for how soft active materials respond to shape-dependent signals, and suggests novel modes of self-organisation at the collective scale.

[1] Erzberger, et al. Nat Phys (2020)
[2] Salbreux, Jülicher Phys Rev E (2017)
[3] Dullweber, Erzberger Curr Opin Syst Biol (2023)
[4] Corson, et al. Science (2017)
[5] Khait, et al. Cell Rep (2016)

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