Self-organized dynamics of freely-jointed active droplet chains

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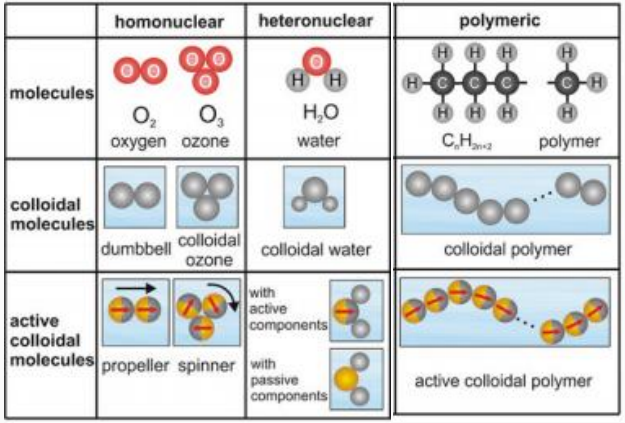
Why are we interested in active assemblies (molecules, superstructures)?

- **Active molecules:**

{Theories for nonequilibrium systems will be challenged- dynamical density functional theory (*J. Chem. Phys.* ***2016****,144,024115*) or mode coupling theory (*Phys. Rev. E* ***2016****, 93,012603*). These theoretical approaches need to be generalized or completely newly founded if activity comes into play}.

- **Active polymers - Activity driven non-equilibrium fluctuations and conformation changes in polymeric or filamentous structures:**

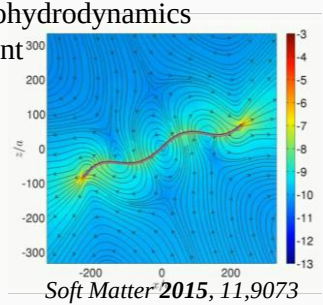
{New physics arises if the background medium is changed towards a complex fluid which can be viscoelastic (*Phys. Rev. Lett.* ***2016****,116,138301*), or if the background itself is another kind of soft matter}.



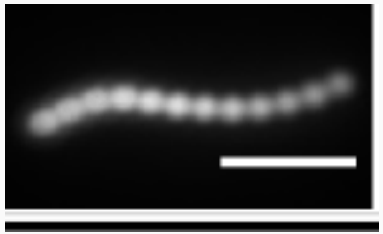
Broadly: Activity driven folding- inspired by the protein folding

https://www.dc.fi.udc.es/ai/~santos/proteins/proteins.html

Brownian microhydrodynamics of active filament



Soft Matter ***2015****, 11,9073*

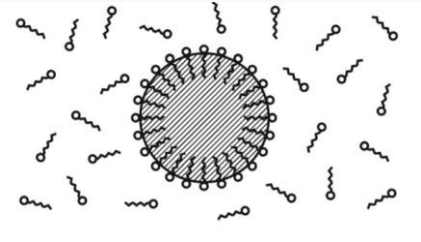


ACS Nano ***2017****, 11(10)*

EPL ***2018,****121,58001*

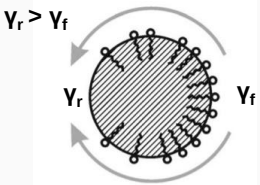
Oil droplet microswimmer – A building-block for active self-assembly

Oil-in-water system

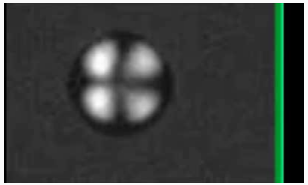


Conc. < CMC

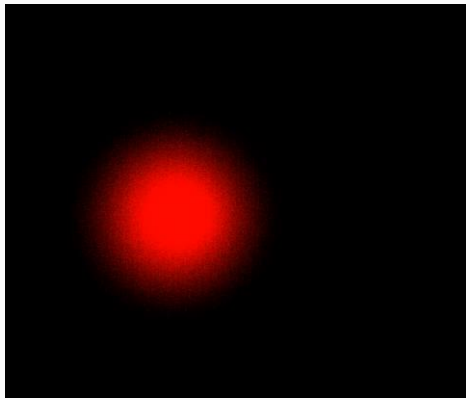
Marangoni flows

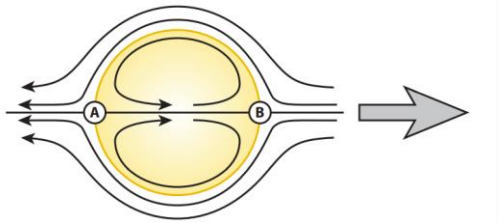


Conc. >> CMC

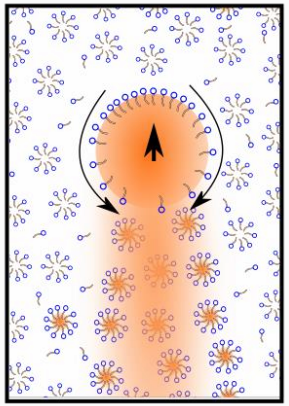


PNAS ***2018*** *115 (21) 5403*





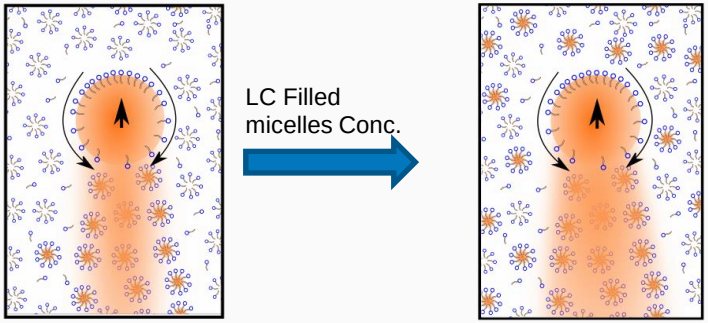
Hydrodynamic field



SDS, 25%

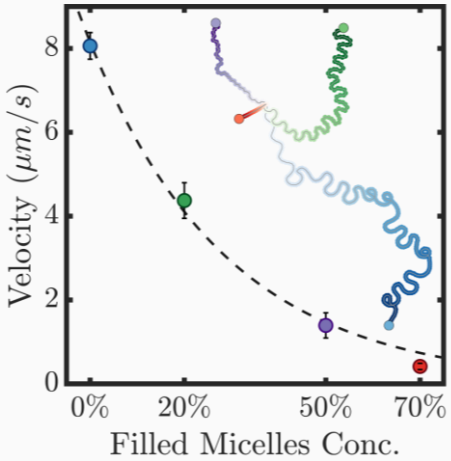
Self-sustained conc. gradient between filled and empty micelles

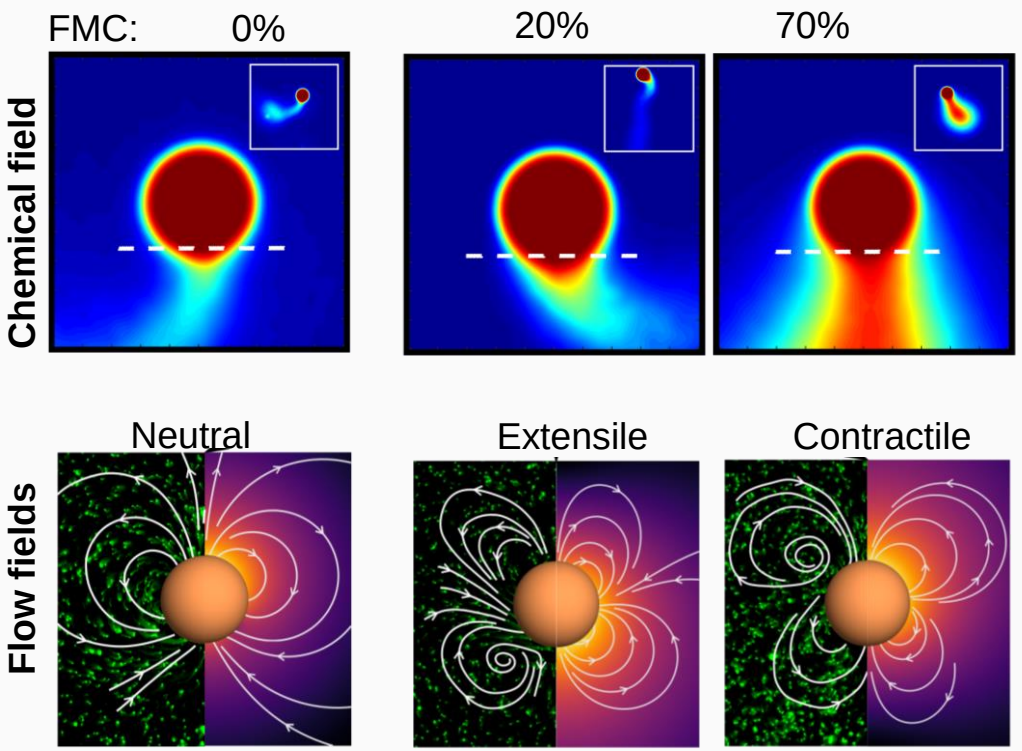
Tuning the slip velocity modulates the droplet flow fields



NO additional filled micelles

With additional filled micelles

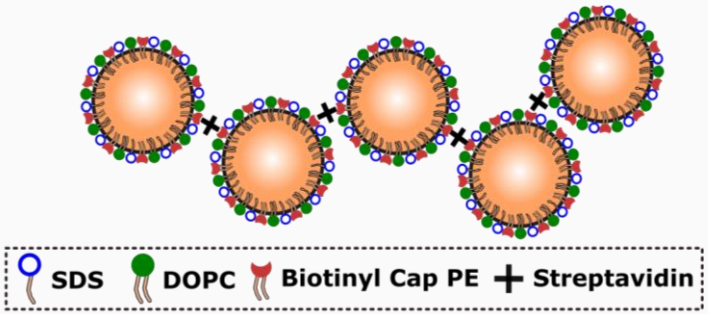




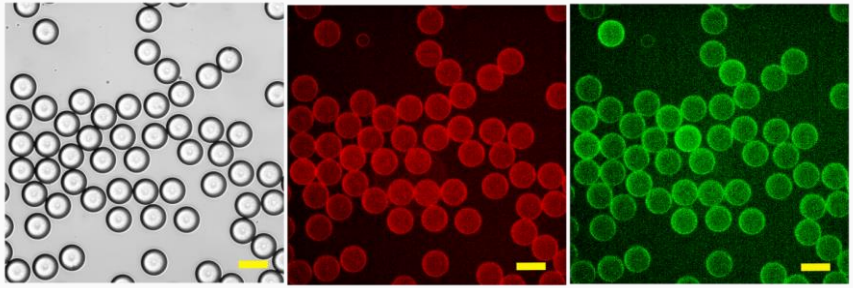
Manuscript under preparation

Formation of freely-jointed chains of droplet swimmer

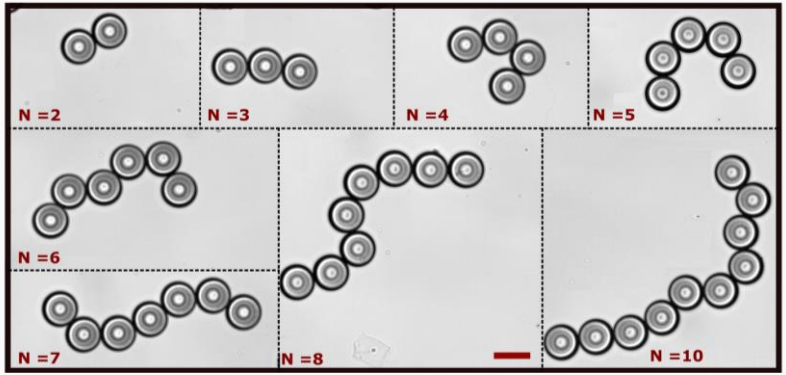
Scheme for making assemblies

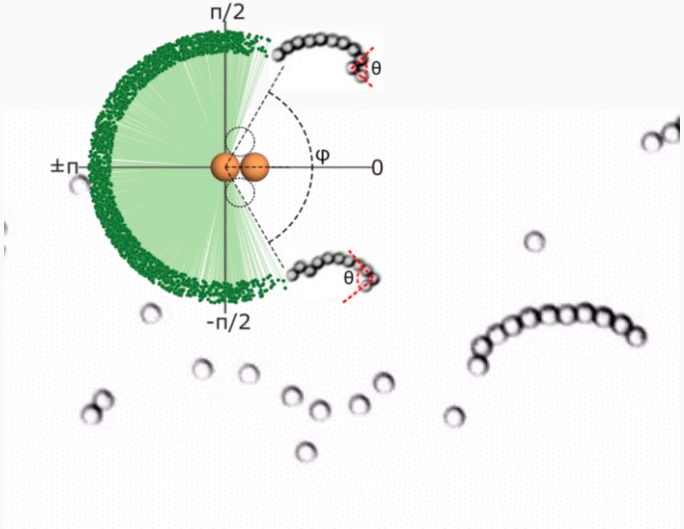


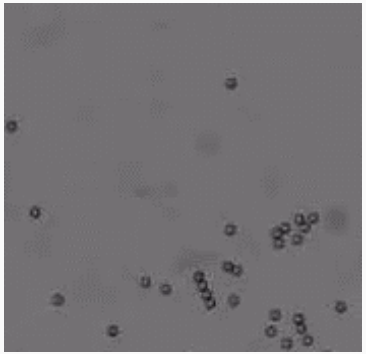
Uniform size droplets, produced using Microfluidics



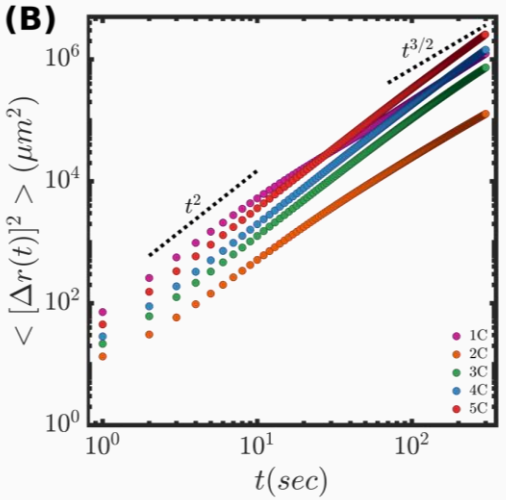
Linear assemblies (Chains)





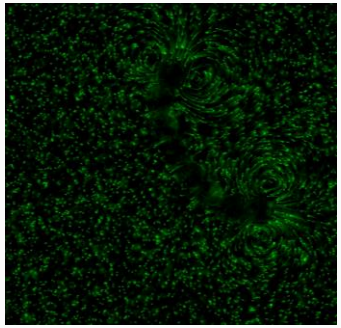


Dynamics of freely-jointed chains of droplet microswimmer

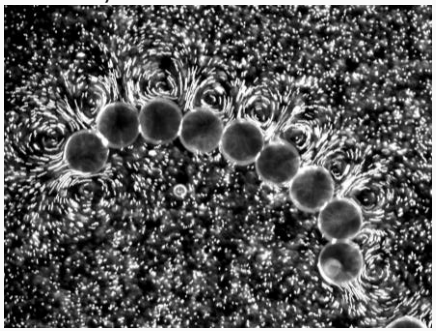


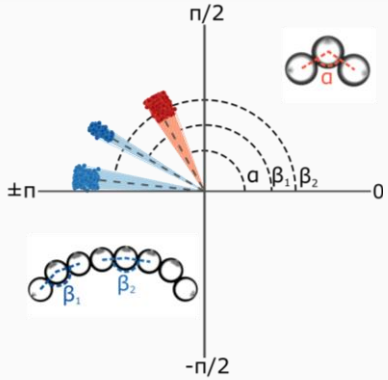
Dynamics of freely-jointed chains with and without LC filled micelles

FMC, 0%



FMC, 70%



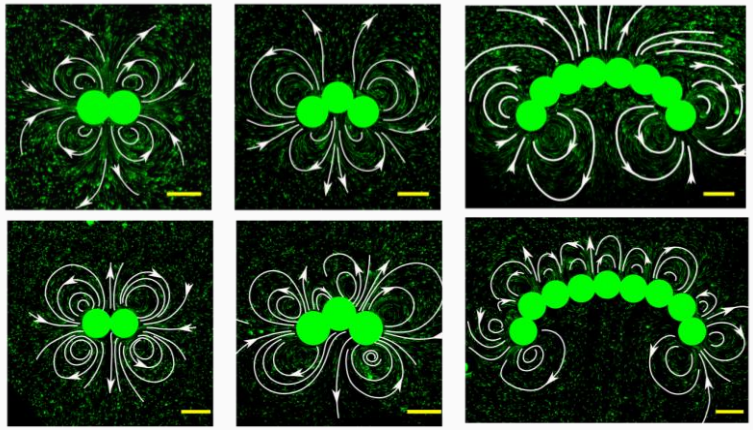


FMC

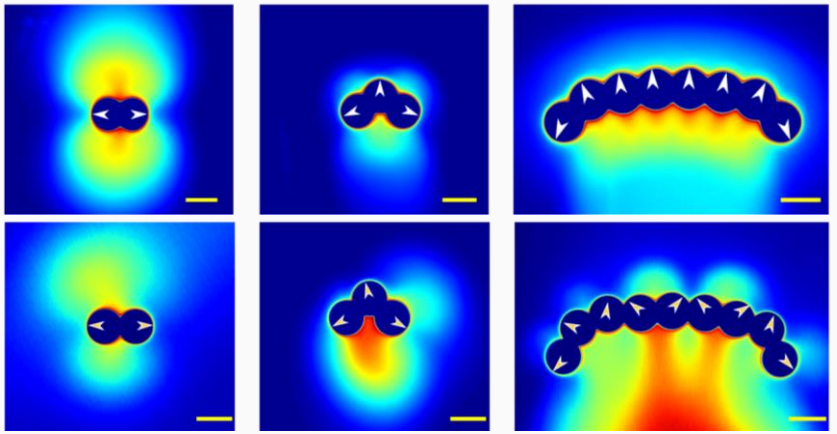
Flow fields

0%

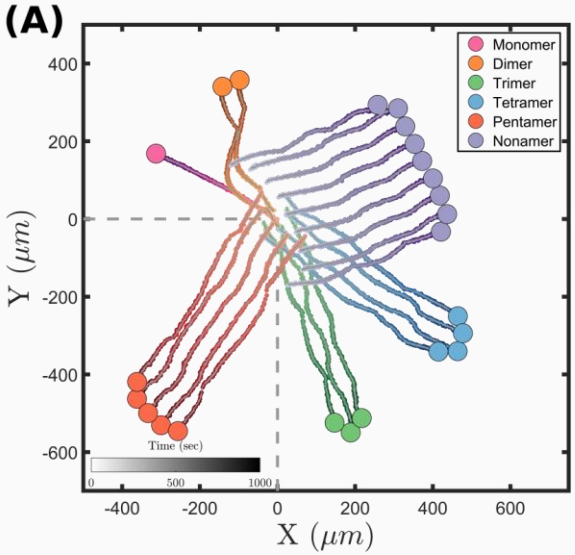
70%



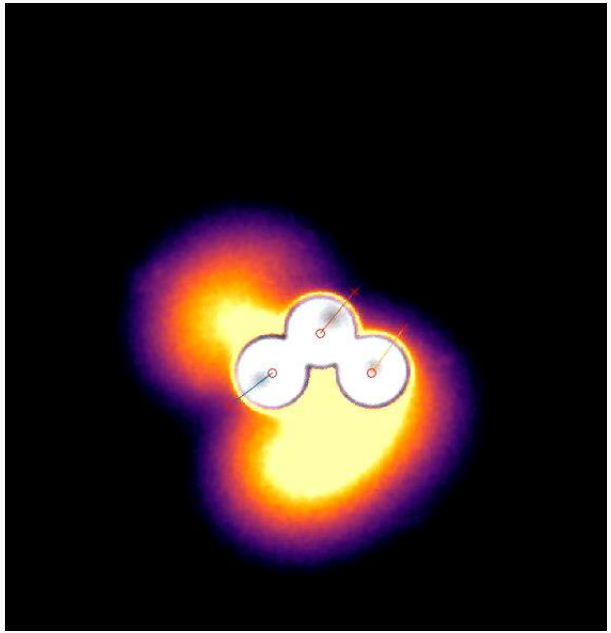
Chemical field



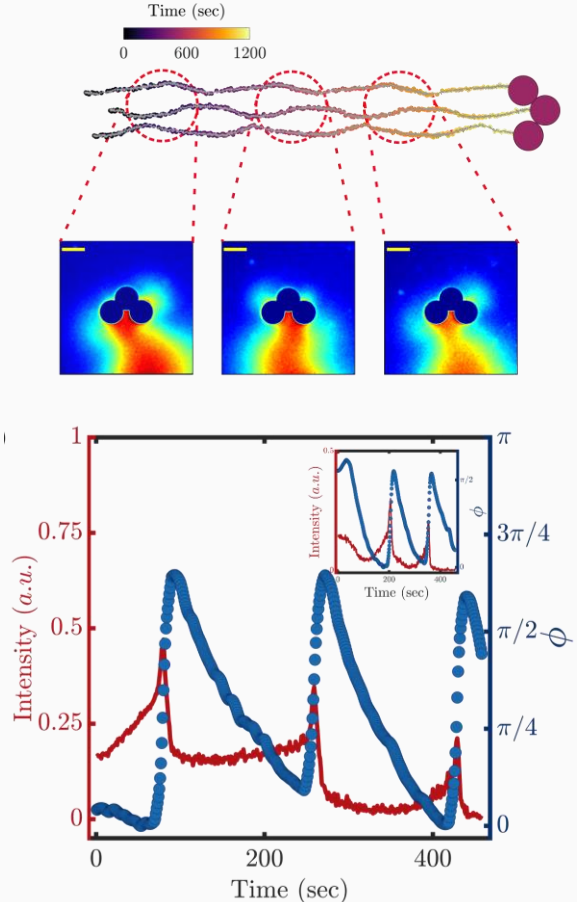
Oscillatory dynamics of the chain dictated by self-generated chemical field



FMC, 70%



Self-generated chemical field

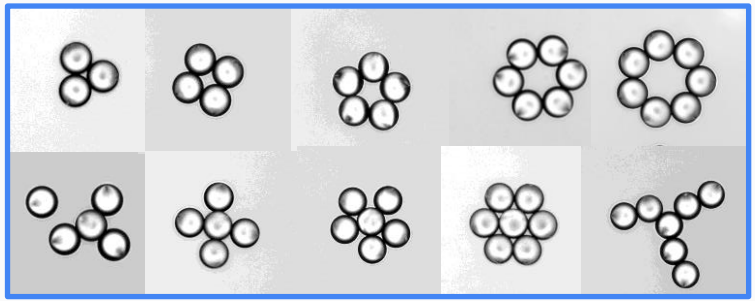


In Summary:

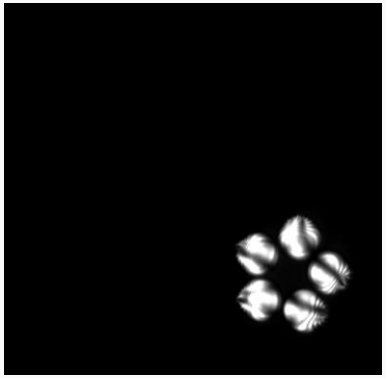
- We form freely-jointed chains of active droplets which can propel- normal to their body axis and along their body axis.
- Tuning of the slip velocity (monomer and linear assemblies) by controlling the self-sustained concentration gradient.
- Hydrodynamic and chemical fields shape each other.
- Oscillatory dynamics of the active droplet chains

Teaser and Other prospects of this work

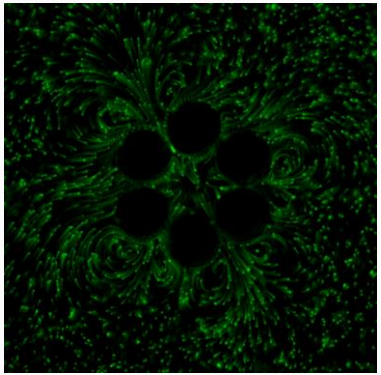
Closed and branched assemblies assemblies

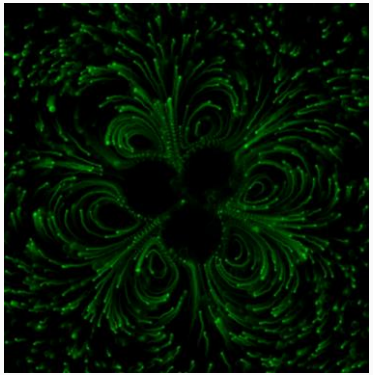


Dynamics



Flow field





Questions

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Thank You..