

Shear thickening, viscoelasticity, and creep of rough colloids

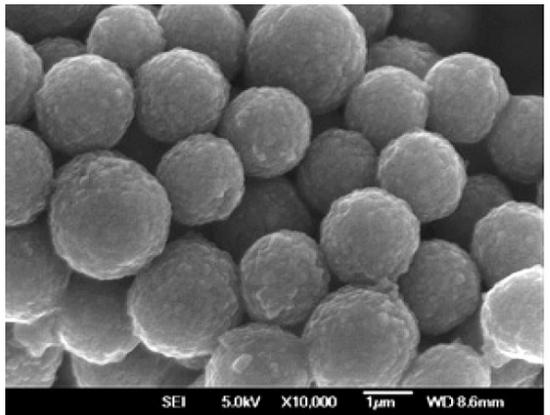
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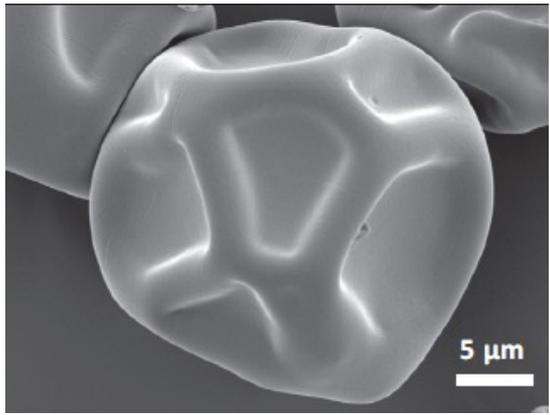
Real, not perfect hard spheres

Coatings

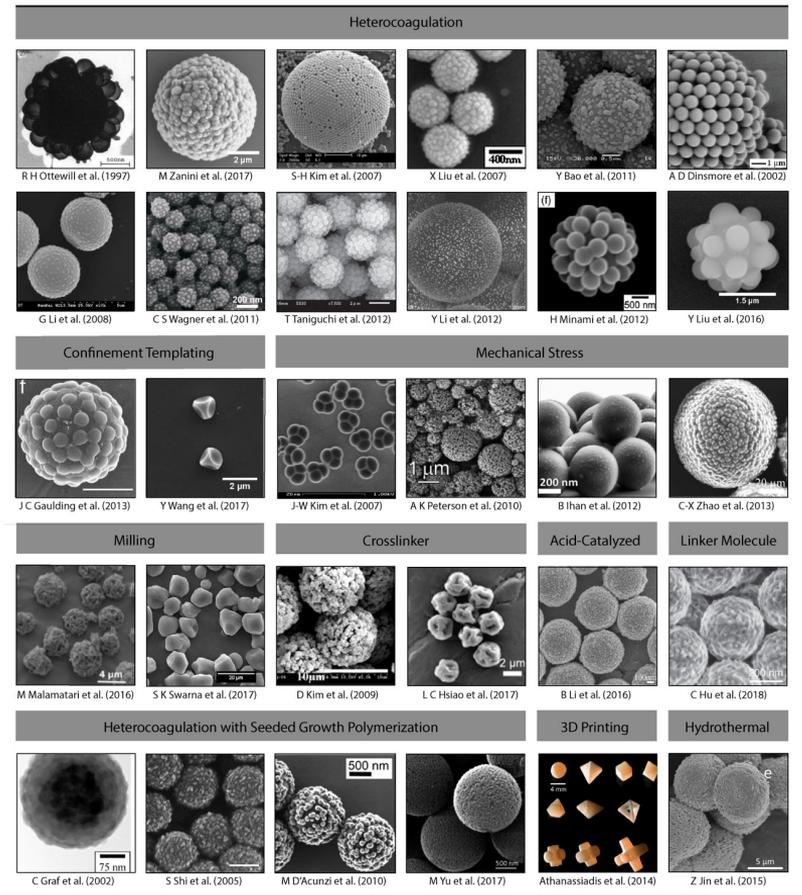


Yin *et al.* *Soft Matter* (2009)

Food powders



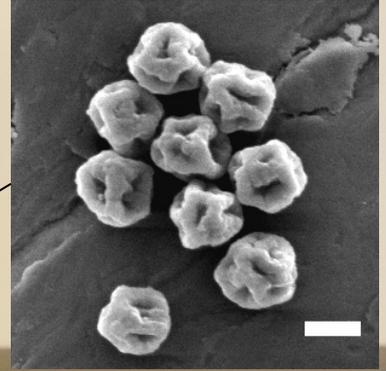
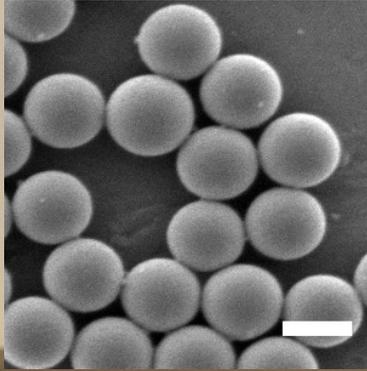
Burgain *et al.* *Progress in Surface Science* (2017)



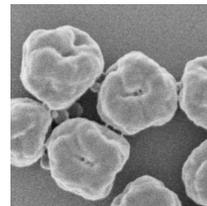
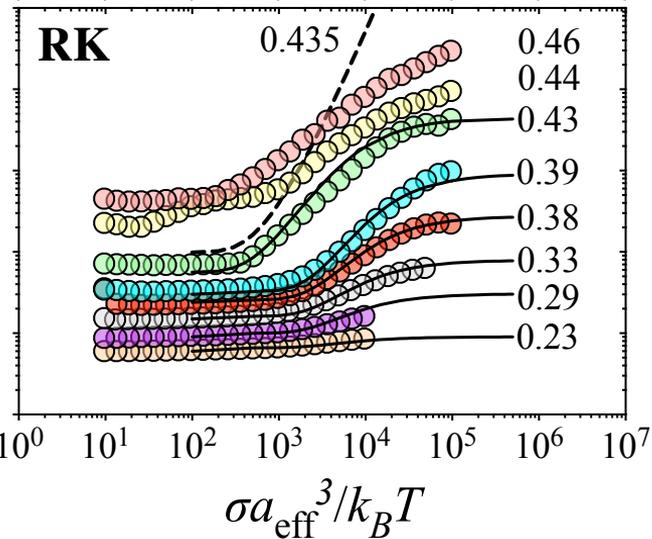
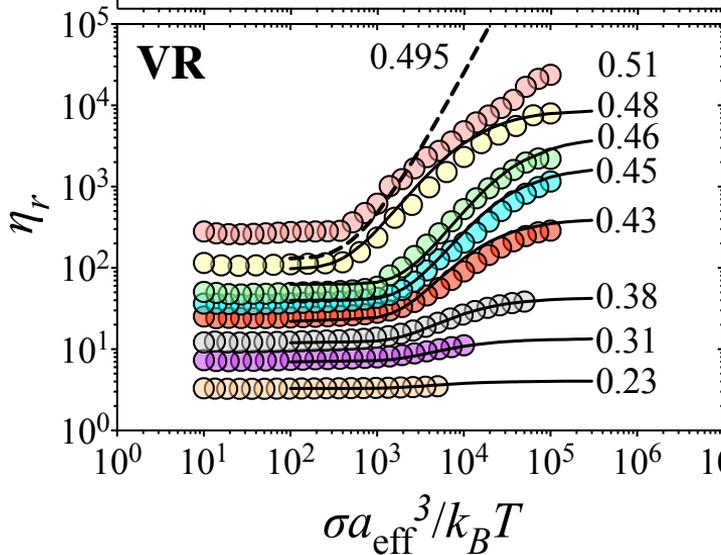
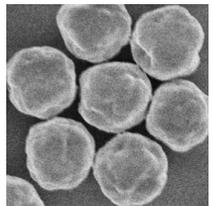
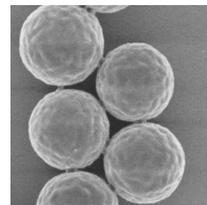
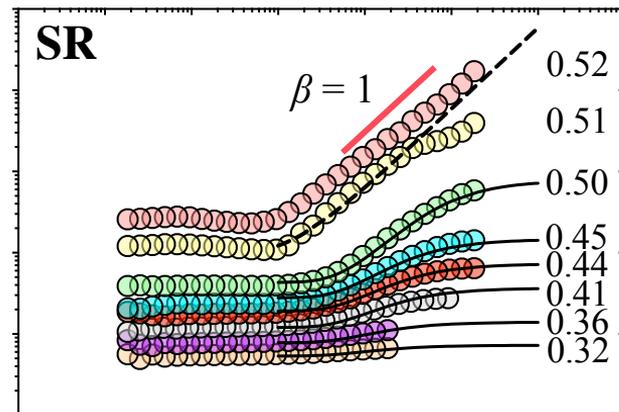
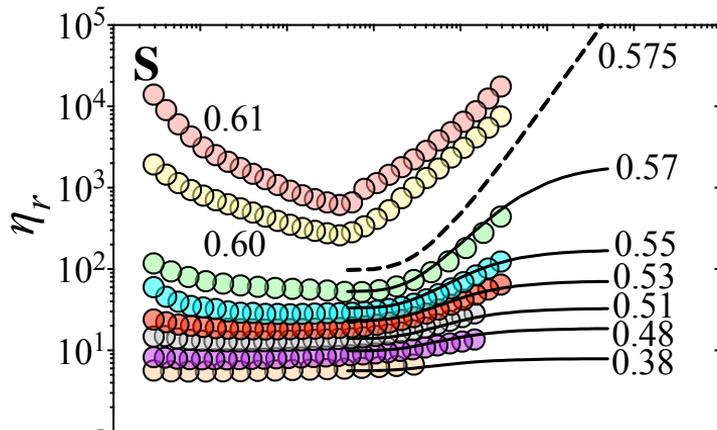
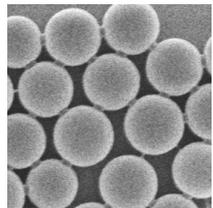
Hsiao & Pradeep. *Current Opinion in Colloid & Interface Science* (2019)

Particle roughness and shear thickening

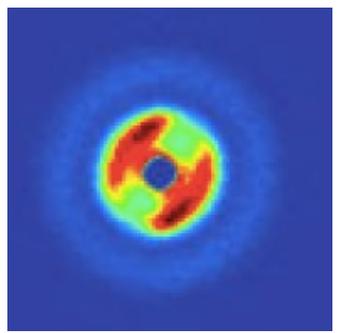
$\phi = 0.52$ for both vials



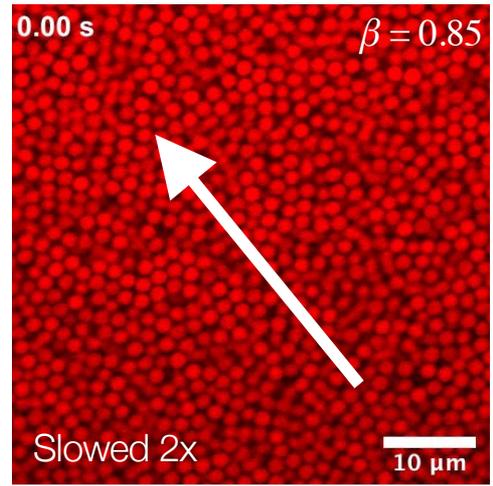
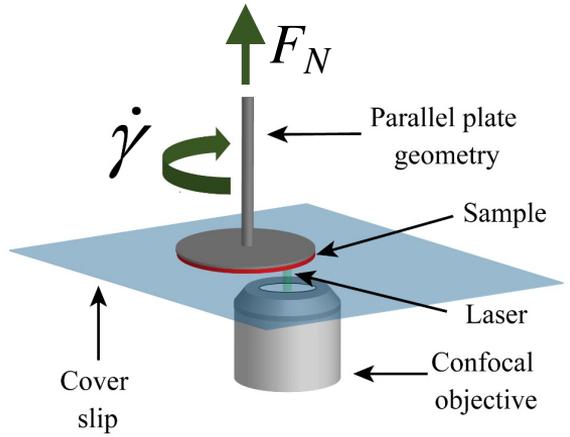
Steady shear flow curves



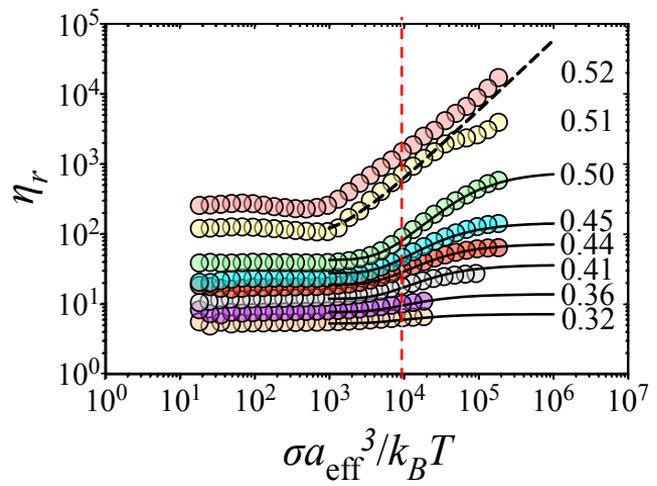
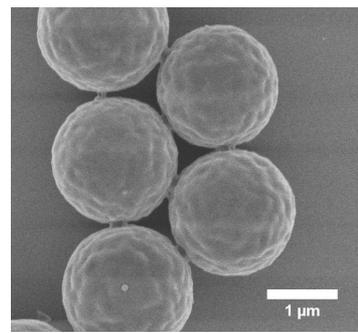
Confocal rheometer for dynamical measurements



Gurnon & Wagner, *JFM* (2015)

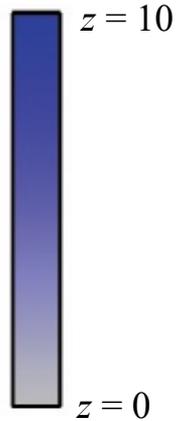
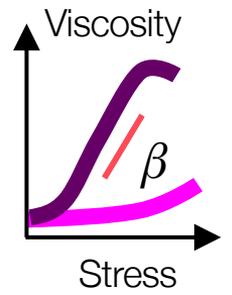
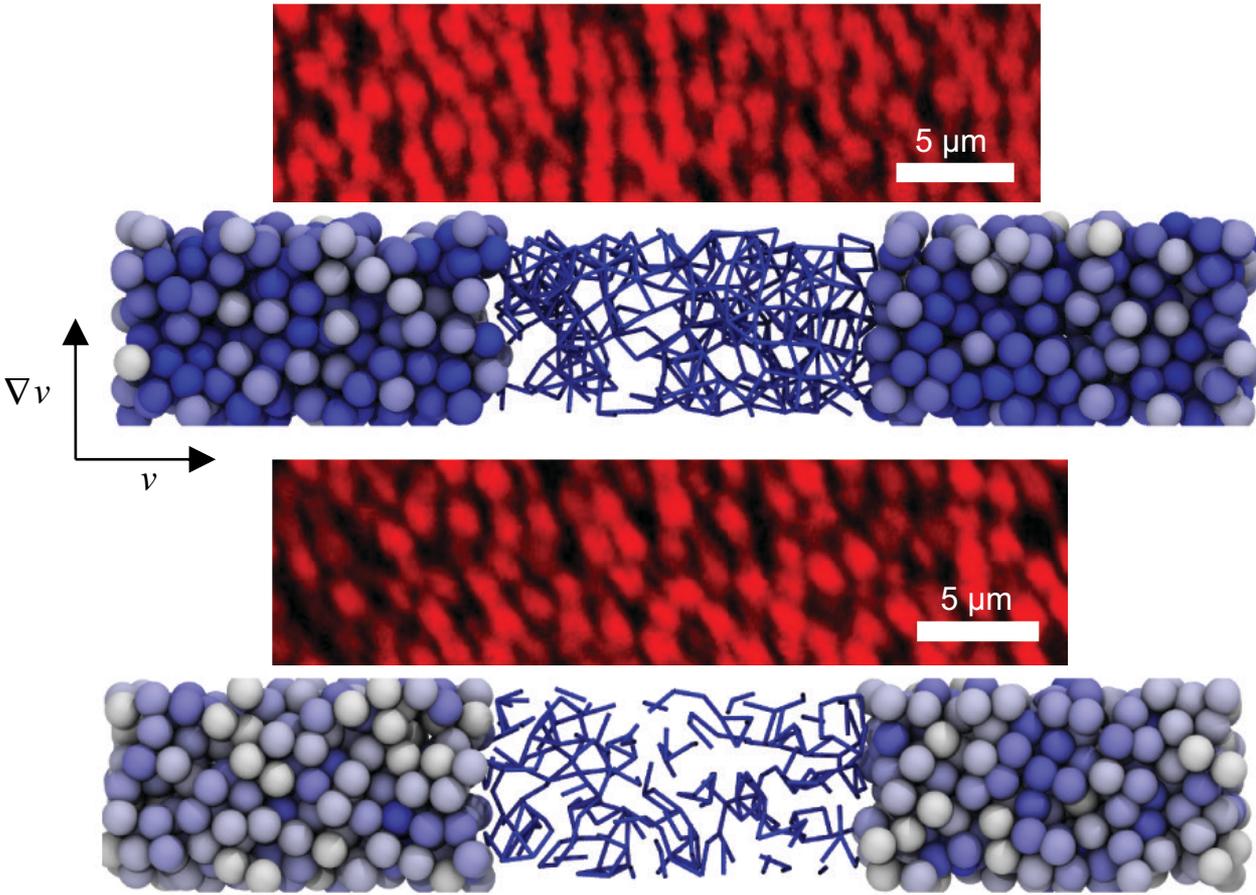
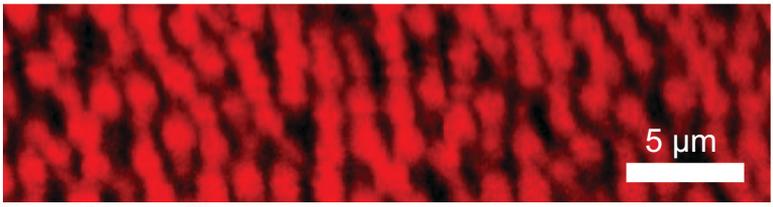
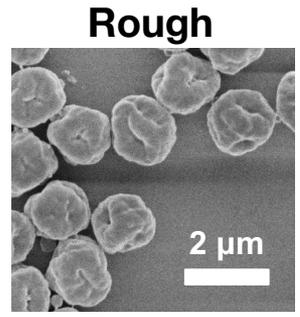
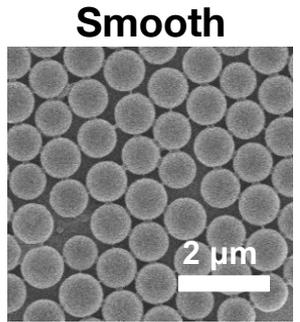


$\phi = 0.52$
 $2a_{\text{eff}} = 1.82 \mu\text{m} \pm 5\%$
 Solvent: Squalene
 Type: Slightly rough PHSA-PMMA

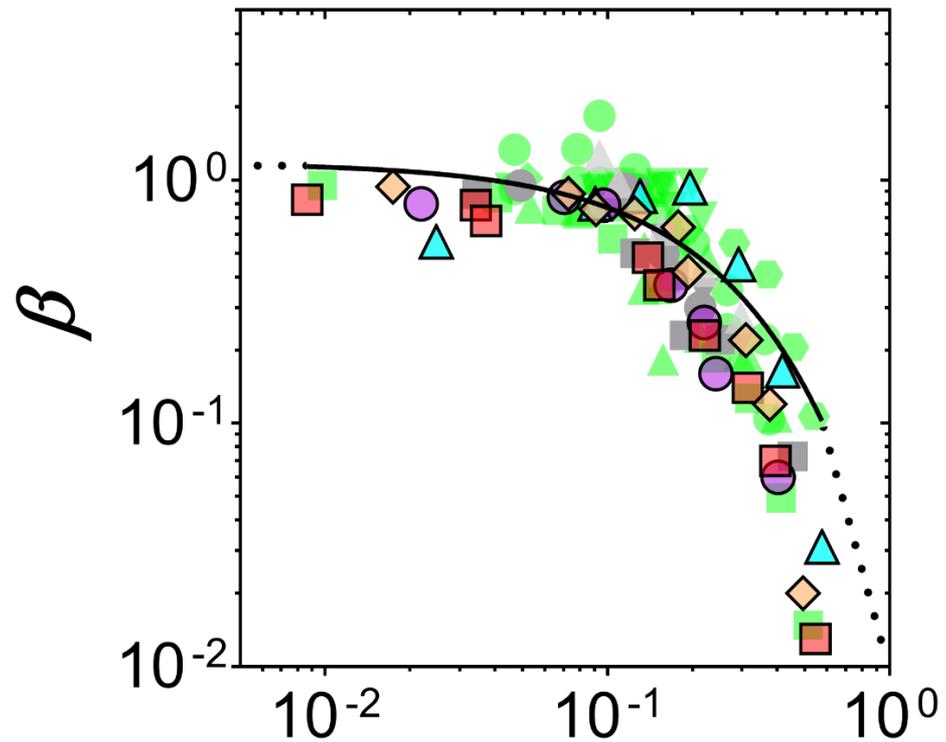
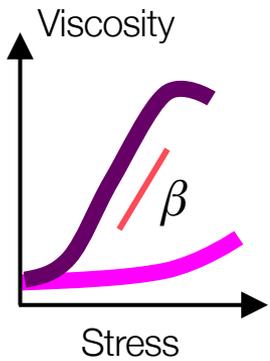


First view of contact networks in colloidal suspensions

$$\beta = 0.85$$



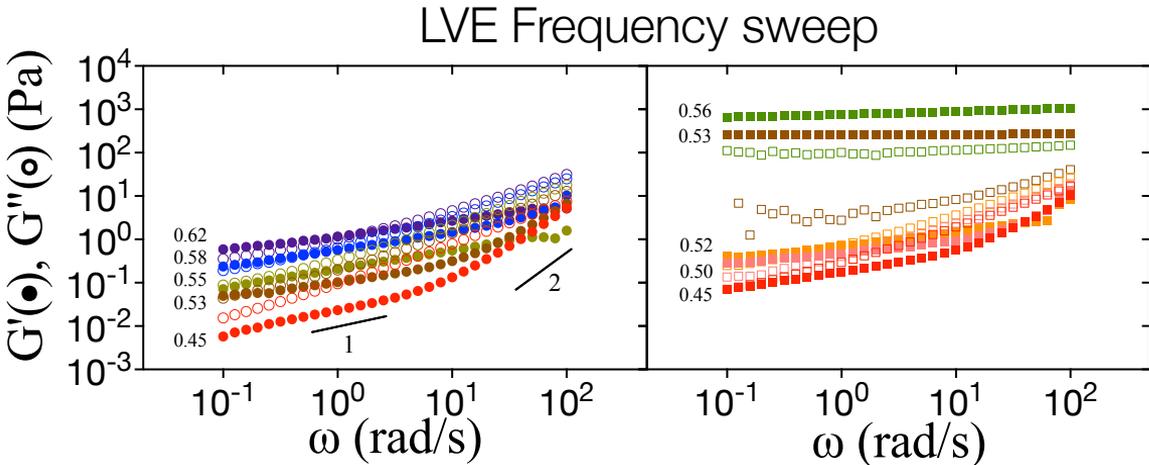
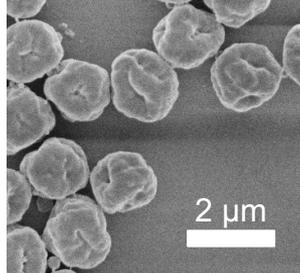
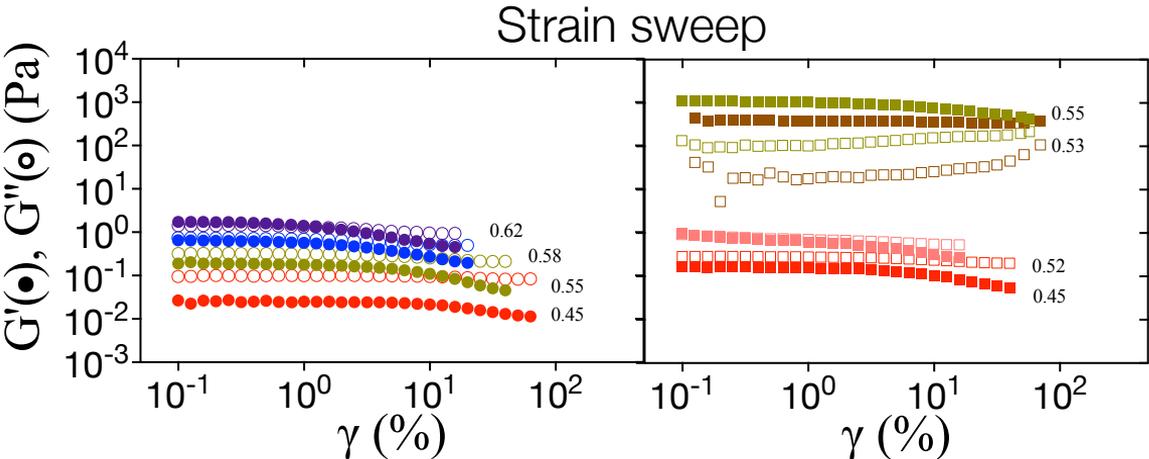
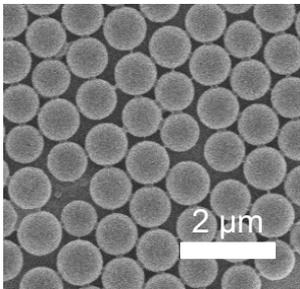
Predicting shear thickening power for colloids



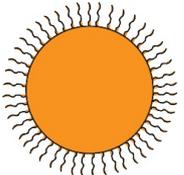
- Experiments
 - Guy et al. PRL (2015)
 - Hsiao et al. PRL (2017)
 - Royer et al. PRL (2016)
 - Cwalina et al. JOR (2014)
 - Hsu et al. PNAS (2019)
 - Lootens et al. PRL (2005)
- Simulations
 - Seto et al. PNAS (2015)
 - Singh et al. PRL (2020)
 - Singh et al. JOR (2020)
 - Jamali et al. PRL (2019)

Concentrated ← $\Delta\phi/\phi_{max}$ → Dilute

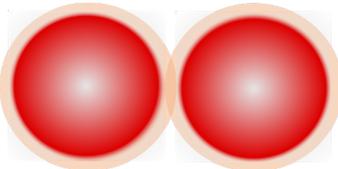
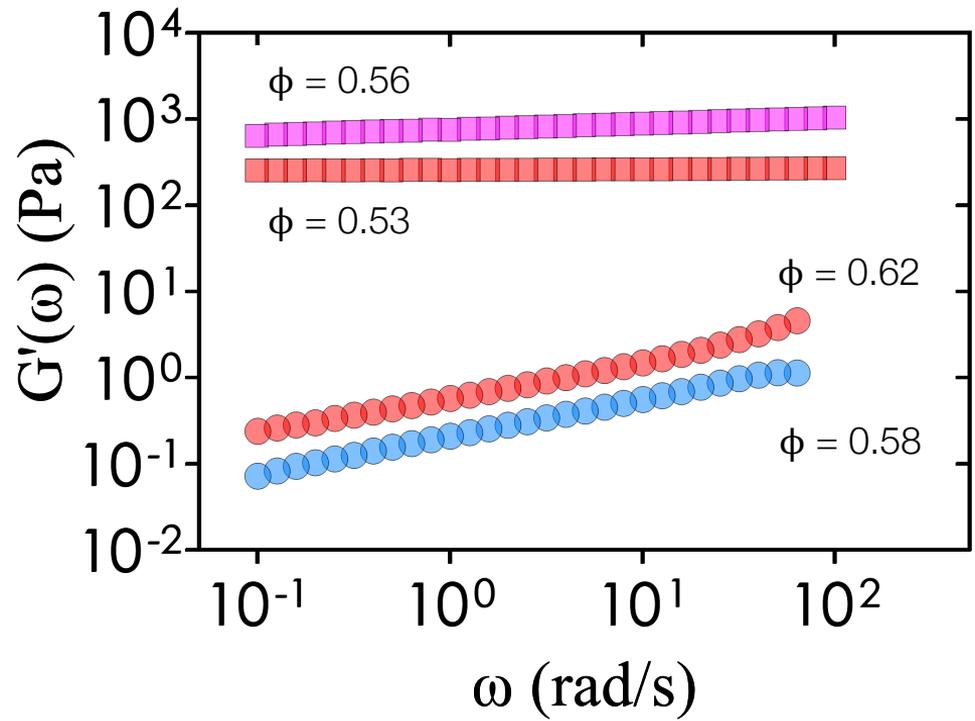
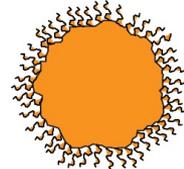
Enhanced viscoelasticity of rough colloids



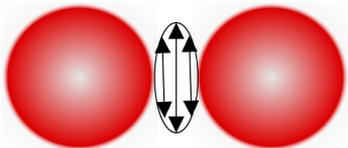
Mechanism for high frequency modulus



$G_{\infty}' \sim \sqrt{\omega}$
Free-draining limit

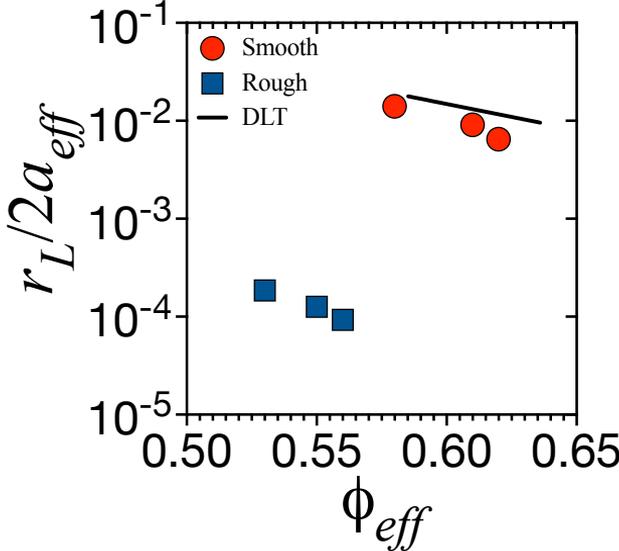
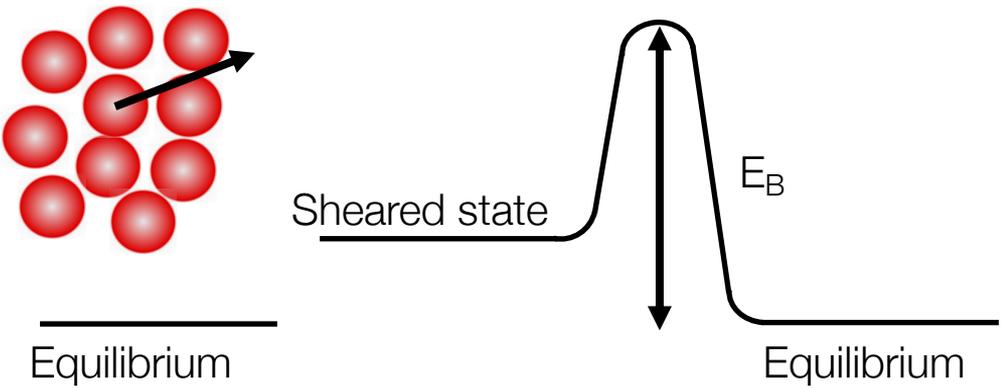




$G_{\infty}' \sim \omega^0$
Hydrodynamic limit



Inter-asperity interactions enhance lubrication interactions between rough colloids

Glassy plateau modulus: Dynamic localization theory

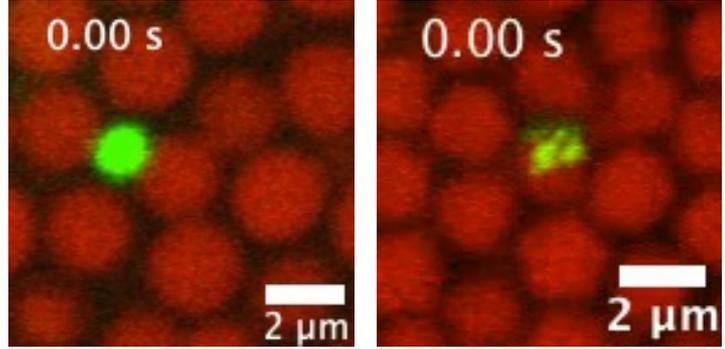


Glassy plateau modulus

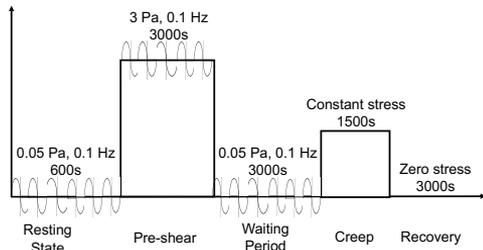
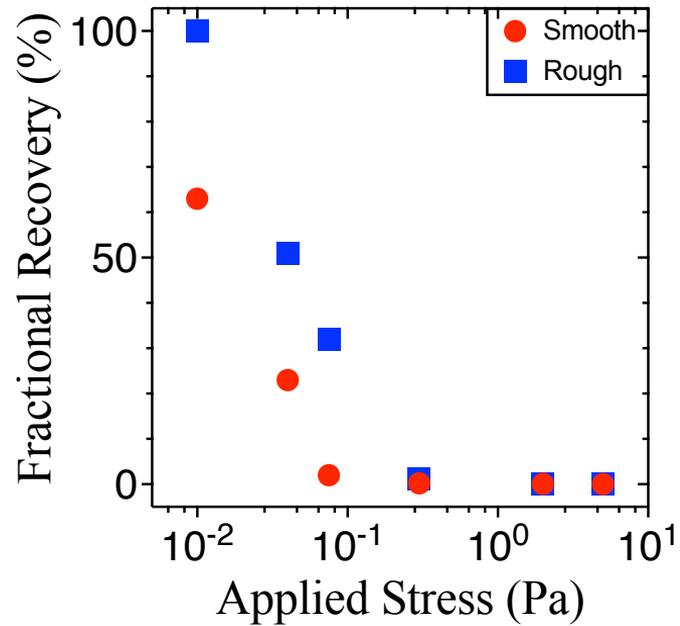
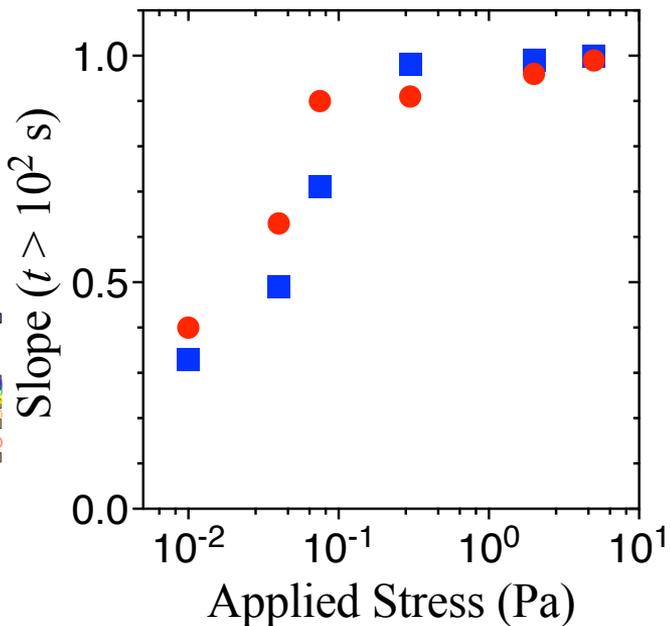
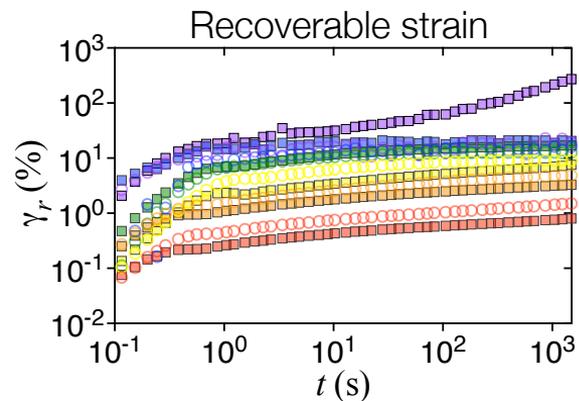
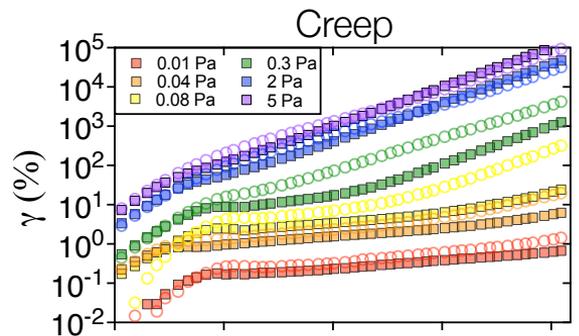
$$G'_P \cong \frac{9}{5\pi} \frac{\phi k_B T}{a_{eff} r_L^2}$$

~ cage length scale

Schweizer & Saltzmann, *J Chem Phys* (2003)



Creep and recovery of rough colloids



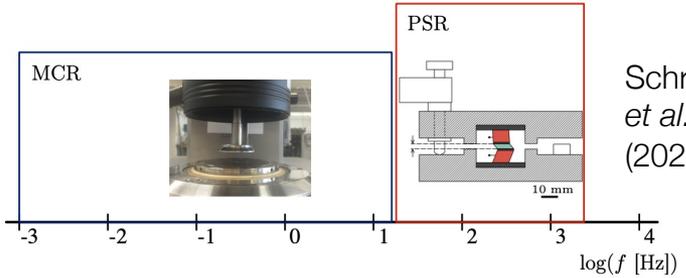
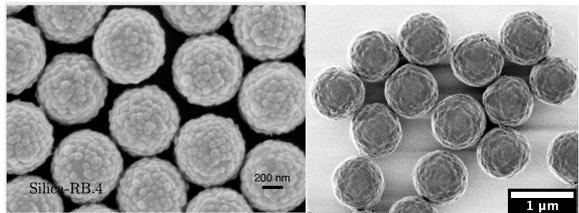
Interlocking between particles reduces creep compliance and increases memory

Planned experiments with the Vermant group

1) High frequency linear rheology of rough colloids

Q: Can we decouple lubrication from electrostatics in high-frequency response?

Piezo shear rheometer (0.001 to 2000 Hz), dense suspensions of PHSA-PMMA and silica raspberry colloids with similar sizes, jamming distances

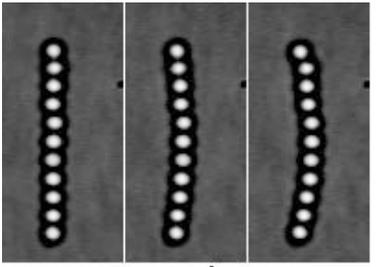


Schroyen & Vermant *et al.*, *Rheo. Acta* (2020)

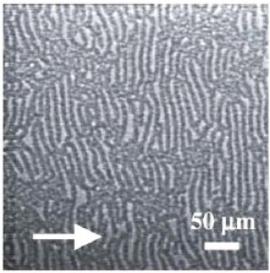
2) Depletion gel log rolling with rough colloids

Q: Do tangential friction lead to different microstructures at low shear rates?

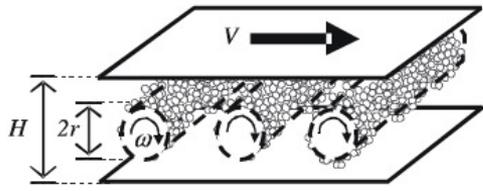
Confocal counter-rotating shearing device, depletion gels of PHSA-PMMA rough colloids



Pantina & Furst, *Phys. Rev. Lett.* (2005)



Vermant & Solomon, *J. Phys. Condens. Matter* (2005)



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Prof. Safa Jamali
Northeastern



Dr. Alan Jacob
IIT Hyderabad



Rony Waheibi



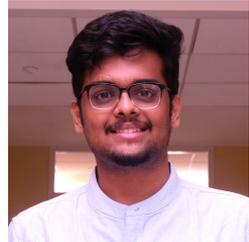
Dr. Shrvan Pradeep
U. Penn



Yug Saraswat



Shourie Yerabati



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June 4-7, 2023

Plenary Speakers



Cari Dutcher
University of
Minnesota



Sibani Lisa Biswal
Rice University



Lillian Hsiao
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Symposium Co-Chairs

SESSIONS

- Active and Adaptive Matter
- Additive Manufacturing and Colloidal Metamaterials
- Colloids and Surfaces for Energy Applications
- Colloids in Biotechnology and Pharmaceuticals
- Gels and Biomolecules
- General Fundamentals and Applications Session
- Machine Learning and AI for Colloids
- Nanoparticles and Nanocolloidal Dispersions
- Rheology & Complex Fluids
- Self- and Directed Assembly
- Wetting, Adhesion and Interfacial Phenomena
- Poster Session
- + Connecting the Dots – Startup to Corporate Level

NC State university will host the 97th ACS Colloid and Surface Science Symposium from June 4-7, 2023.

This yearly event brings together world-class invited speakers and an international community of researchers from a wide range of related disciplines, from surfactants and biomolecules to nanoscience and environmental studies.

Raleigh is a growing research hub, boasting the Research Triangle Park, NC State's beautiful Centennial Campus and other industrial and educational pioneers.

Attend the conference and enjoy a wide variety of local attractions such as eclectic eateries, murals and museums.