Shaqfeh Research Group
Suspension mechanics, non-Newtonian fluid mechanics, particle motion in flow, & non-equilibrium polymer physics

Particle-laden viscoelastic fluids
Viscoelastic suspensions are ubiquitous in industrially-relevant applications, where it is critical to understand the flow behavior:
- Difficulty applications
- Separation or fluctuation
- Microfluidics
- 3D printing

Rheology of viscoelastic suspensions
Mengfei Yang, Jonas Einarssson
- The bulk material properties of viscoelastic suspensions are difficult to predict due to the nonlinear fluid stress.
- The interactions between the suspended rigid particles and the suspending elastic fluid lead to interesting stress contributions.

Immersed boundary method for VE suspension flows
Sreenath Krishnan
- An immersed boundary method has been developed which allows for large-scale simulation of suspensions of particles in Newtonian and viscoelastic fluids.

Particle sedimentation in VE fluids
William Murch, Sreenath Krishnan, Jonas Einarssson
- Viscoelastic fluids are used in fracturing fluids to help suspend particles.
- Particle settling velocities are reduced in sheared polymeric fluids due to extended regions of polymer stretch.

Deformable particles in bio-fluids
Hindered mobility of vesicles in channel flows
Joseph Barakat
- Squeezing a vesicle can induce membrane poration, enhancing permeability to pharmacological molecules for targeted delivery applications.
- The excess pressure drop $\Delta p^*$, an experimental measurable, is used to gauge hindered mobility and membrane tension.

Finite element method for deformable particles
Chris Guido
- In addition to simulation of rigid particles in viscoelastic flows (see left panel), deformable particle suspensions are also of interest.
- An Immersed Finite Element (IFEM) implementation is utilized for the solid mechanics coupled to our group's finite volume fluid solver.
- Currently this solver is in validation for simple flow cases. To the top left is the shape of a particle with Capillary number $G=0.05$ compared to a perturbation result in shear flow. The bottom left is an example of polymer stretch in the fluid at Capillary number (G) .01 and Weissenberg number (Wi) 1.

Red blood cell migration and platelet margination
Qin (Maggie) Qi, Amir Saadat
- The blood suspension consists of red blood cells and platelets. Due to their difference in deformability, red blood cells migrate away from the wall and platelets marginate towards the wall.
- RBC migration and platelet margination are important in hemostasis, thrombosis and microfluidic applications.
- We use large-scale simulations (top), semi-analytical theory (middle) and microfluidic experiments (bottom) to study migration and margination phenomena.

Drug delivery and transport
Nanoparticle drug delivery for cancer therapy
Tiras Y. Lin
- As a cancerous tumor grows, small pores in neighboring blood vessels develop as a result of the increased need for nutrients.
- Using Brownian dynamics simulations and lab experiments, we investigate the effect that the shape and size of nanoparticles has on their extravasation rate.

Aerosols and particle deposition in lungs
Taylor Geisler
- Understanding the fate of inhaled aerosol particles (medications, pollution) is critical for targeted drug delivery, toxicology.
- Using large-scale simulations alongside in vivo and in vitro experiments, we investigate the complex, turbulent flow in lungs and its effect on inhaled micro-particles.