Squishy Physics: Characterizing the Rheological Properties of Soft Condensed Matter

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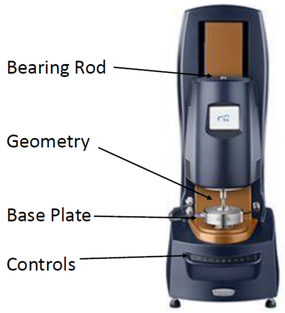
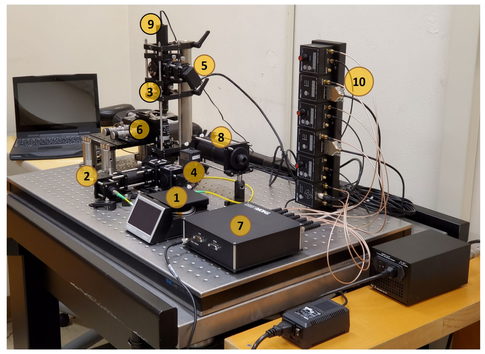
PROBLEM STATEMENT

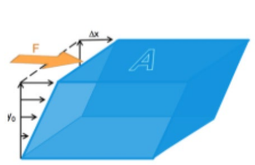
We operate a center specializing in the characterization of soft condensed matter systems using an array of rheological tolls.



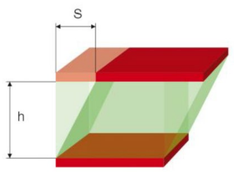
DHR Rheometer: Instrument used in experiments measuring deformation and flow of samples.



1. Laser Diode, 976 nm, 900 mW
2. Beam Expander Segment
3. Vertical Segment
4. 1280x1024 CMOS Camera
5. Back Focal Plane Quadrant Detector
6. Stage with Translation
7. Calibration Module
8. Fluorescence Module
9. Bright-field LED Illumination Source
10. Stage and Quadrant Detector Control Cubes



Stress = $\sigma = \frac{F}{A}$



Strain = $\gamma = \frac{S}{h}$

Figure 1: Our lab's bulk rheometer (left) used to quantify bulk mechanics, and optical tweezers instrument used to conduct microrheological measurements in soft condensed matter.

BACKGROUND

Rheology is used to characterize the mechanical properties of a wide range of materials. We specialize in viscoelastic soft condensed matter (biological gels, polymer networks, rubbers, and fluids). We house three instruments:

- A ***bulk shear rheometer*** to characterize the bulk materials properties, such as viscosity, elasticity, and structural strength, of solids and fluids.
- A ***laser tweezers***, which optically trap and manipulate µm-sized beads in transparent soft materials to a precision of roughly 10 nm, allowing for local active microrheology in transparent samples.
- A ***high-sensitivity force-extension rig***, which allows for high-precision length control and force measurements in the µN- and mN-range, used to characterize soft matter samples, such as smooth muscle tissue.

SUMMARY OF WORK

Our instruments can be applied to a broad range of soft condensed matter samples. We have experience applying our instruments to characterizing polymer networks, such as filamentous actin and intermediate filaments; the interior of living cells to determine intracellular mechanics, and smooth muscle tissue from *Drosophila* flies, a model system used due to its genetic similarities to humans.

Figure 2: Our lab's soft matter linear extension instrument, mounted on a light microscope.

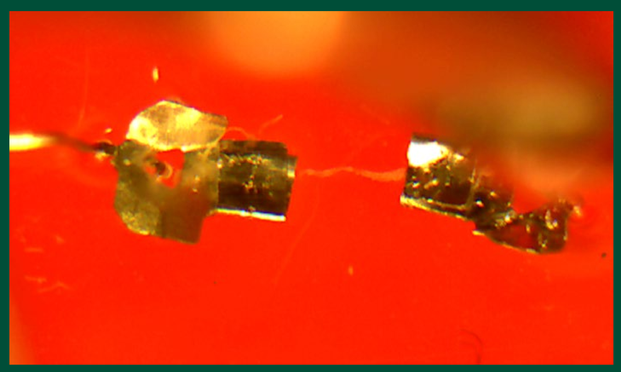


Figure 3: Microscopy image of a dissected Drosophila gut mounted between two clips on the force-extension instrument.

IMPACT ON COMMUNITY

When applied to biological soft matter, rheology is a powerful tool which elucidate biological function as well as the physics of these complex systems. Examples of applications include:

- Biological matter, such as polymer networks, biofilms, or tissue.
- Complex fluids, such as emulsions or colloid suspensions.
- Soils and soil mixtures.
- Rubbers, polymer melts, or similar substances.
- Food products, and artificial food substitutes.
- Any many others!

The equipment, which is currently housed in Sequoia Hall 139, is ***intended as a collaborative facility***. Please reach out to us if interested, or read more at: ***https://squishyphysics.weebly.com/facilities.html***.