Rheometry of Corn Starch Suspensions

Quinn MacPherson

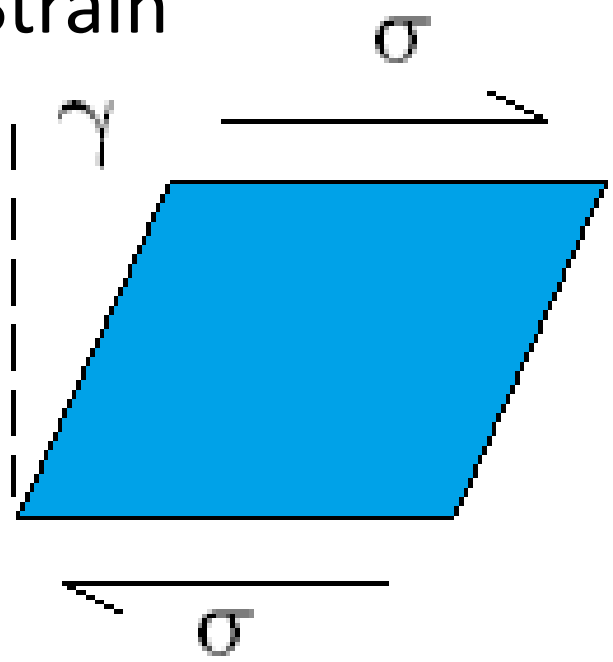
Advisor: Dr. Deegan

Rheometry

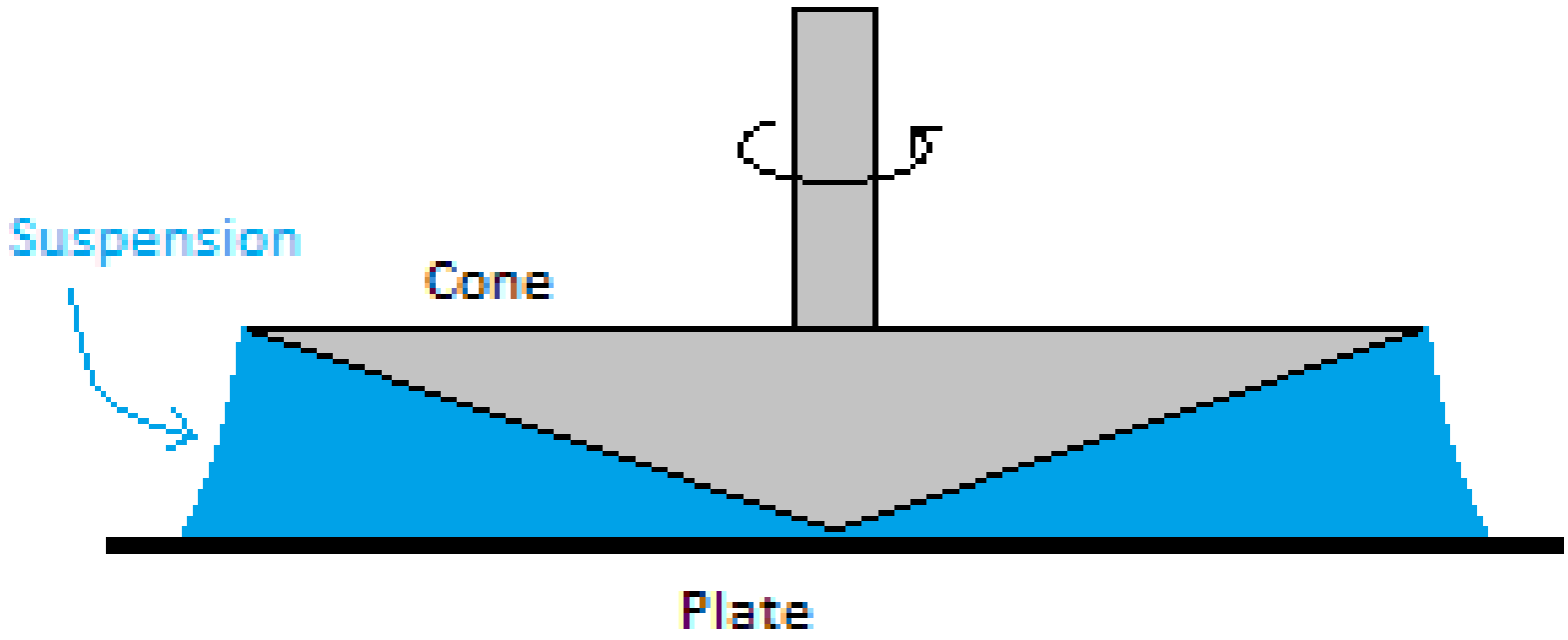
$$\gamma, \frac{d}{dt}\gamma, \ldots, \frac{d^n}{dt^n}\gamma \quad \longleftrightarrow \quad \sigma, \frac{d}{dt}\sigma, \ldots, \frac{\partial^n}{\partial t^n}\sigma$$

Stress

Strain

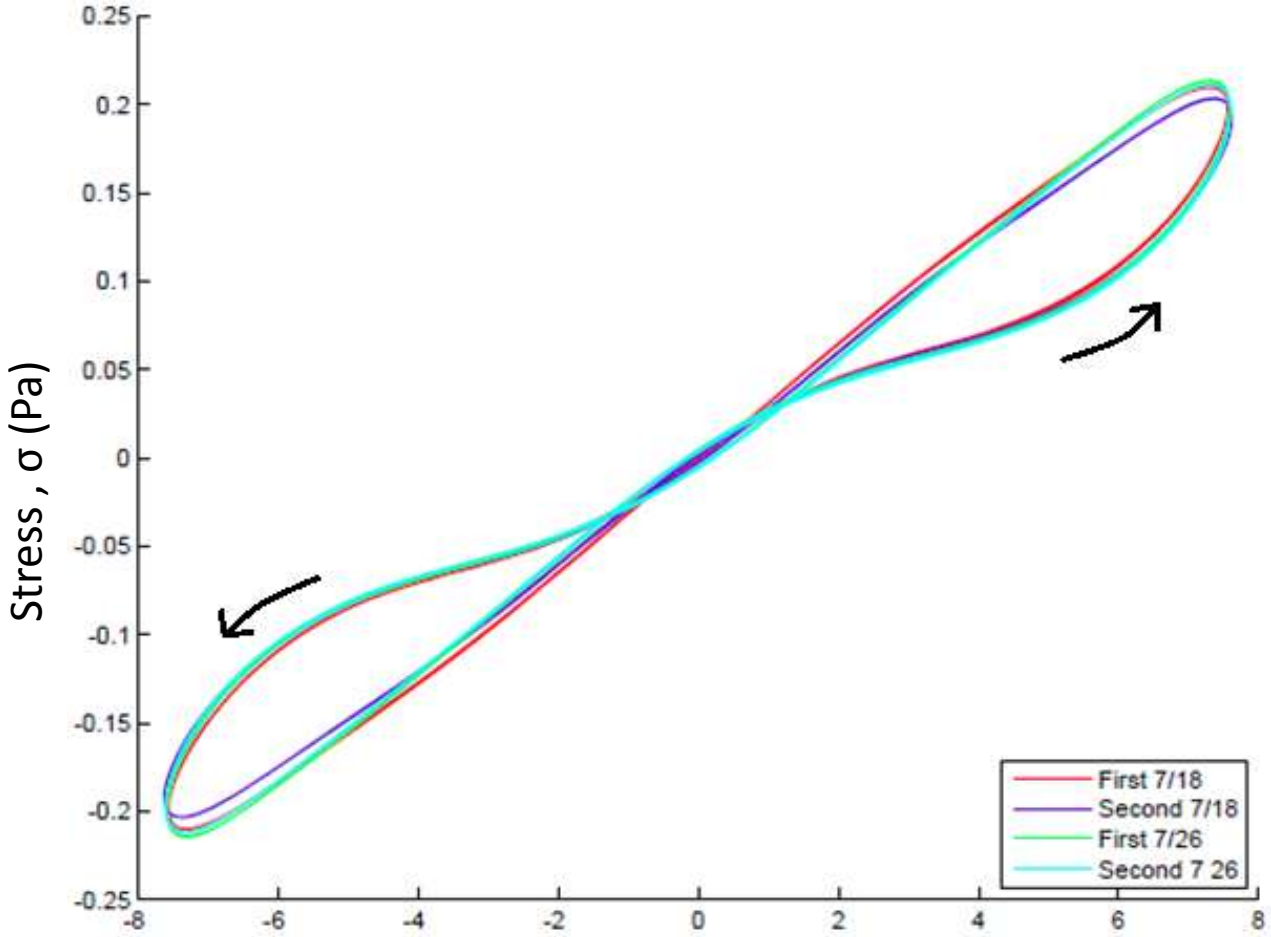


Cone and Plate Geometry



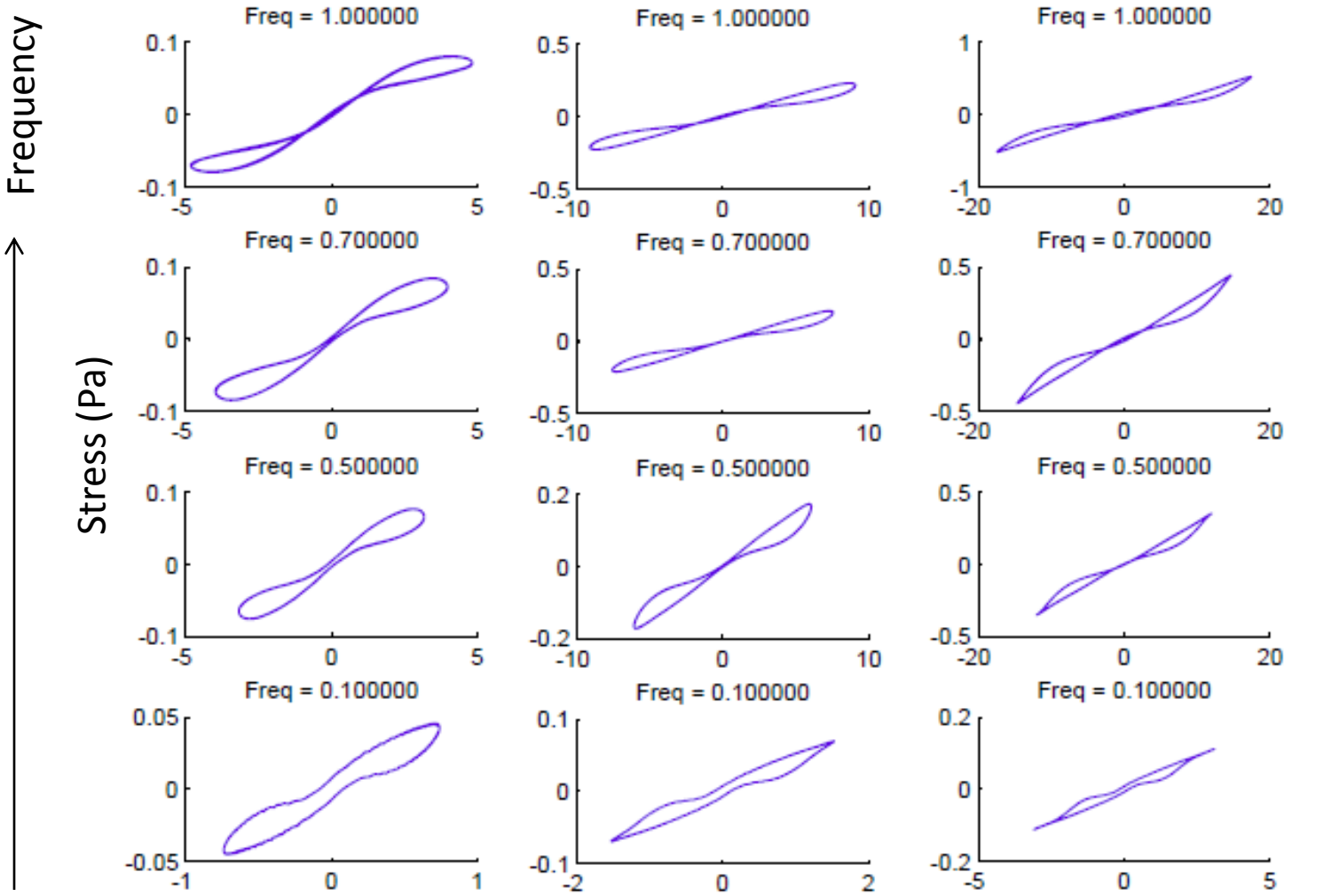
Rheometer geometry for measuring stress vs. strain rate.

Lissajous curves at 0.7 Hz

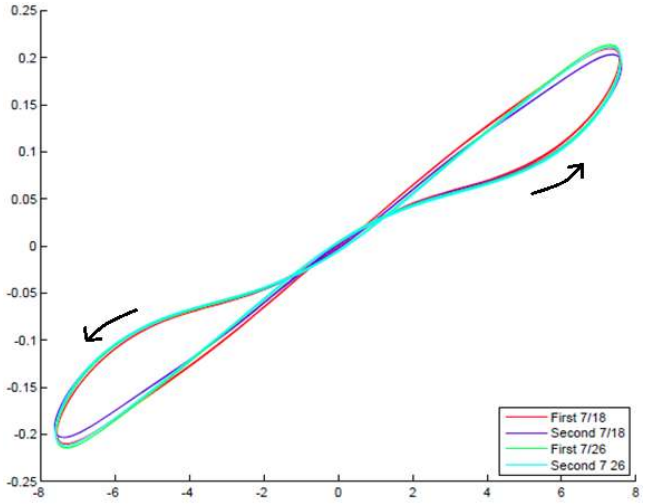


Strain Rate, dγ/dt (1/s)

Variety of Lissajous curves at 0.7 Hz



Stress , σ (Pa)

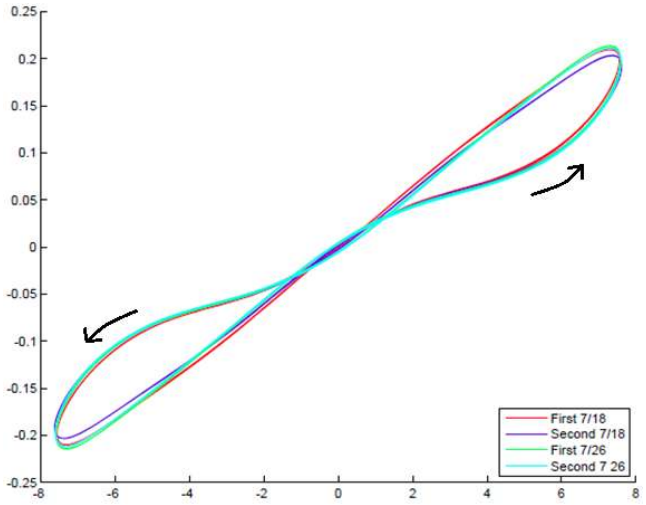


Strain Rate, dγ/dt (1/s)

Eureqa

$$\frac{d}{dt}\gamma = f(\sigma, \gamma, \ldots)$$

Stress , σ (Pa)



Strain Rate, dγ/dt (1/s)

Eureqa

$$\frac{d}{dt}\gamma = f(\sigma, \gamma, \phi, \ldots)$$

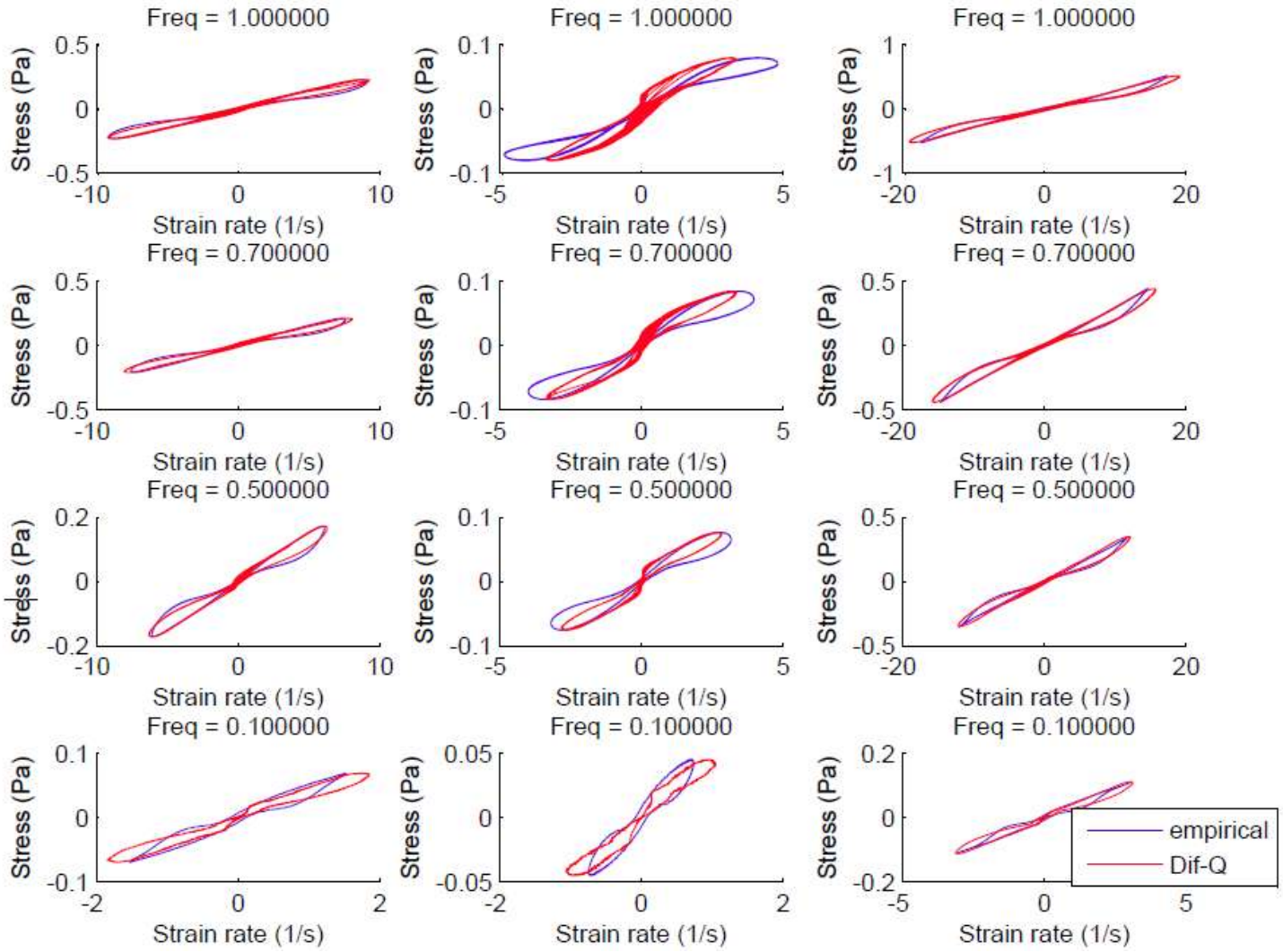
$$\frac{d}{dt}\phi = f(\sigma, \gamma, \phi, \ldots)$$

The best so far…

$$\frac{d}{dt}\gamma = c_1 \sigma + \frac{c_2 \frac{d}{dt}\sigma \, |\sigma| - c_3 \sigma^3}{c_4 \phi + \sigma^2} - \begin{cases} c_5 \frac{\sigma}{|\sigma|} & \text{if } |\sigma| > 0.02\,\text{Pa} \\ c_5 & \text{otherwise} \end{cases}$$

$$\frac{d}{dt}\phi = -\frac{\phi}{\tau} + \left|\frac{d}{dt}\sigma\right|$$

How well does it fit?



Conclusions

- Hysteresis in Stress vs. Strain Rate Curves have interesting shapes and are relatively reproducible.

- There is likely a unknown state variable and therefore Eureqa is incapable of finding the differential equation that fits the data.

Acknowledgements

- Dr. Deegan
- Dr. Campbell and Dr. Liu
- Schmidt and Lipson
- NSF

Questions?