Coaxial Shear Magnetometry: Measuring Order in Magnetic Suspensions under Shear and Magnetic Fields

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Why Order the Dispersion?

- Acicular magnetic particles can be oriented in the dispersion by applying a magnetic field and/or a shear field.
- Ordered dispersions can result in higher data storage. (Thinner, smoother, ordered coatings)
Theoretical Predictions

- Recent models can predict the extent of ordering in the fluid (given by order parameter $S$)
- Need to measure order in dispersions

$S = 1$ : perfect prolate order

$S = -1/2$ : perfect oblate order
Particle Order versus Magnetic Field and Shear Rate

- Increasing the magnetic and shear fields, increases the order
Measuring Order

• How do we measure orientation of nanoscale particles under simultaneous magnetic and shear fields?

• Principle of magnetic susceptometry.
  – An AC magnetic field is applied to the fluid
  – The particles “wiggle” in the field
  – The strength of the “wiggle” indicates the average direction of the particles
AC Susceptometer

- AC solenoid coil
- Fluid sample
- Lock-in Amplifier
- Data Acquisition
- Computer
- DC magnet
- Power Amplifier
- DC magnet controller
- Magnetometer

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AC Susceptibility

- Probes the motion of magnetic particles in a small-amplitude AC field in the presence of a perpendicular DC field.
- Types of Experiments:
  - Measure susceptibility
  - DC field amplitude sweep
  - Transient response to DC field
  - AC frequency sweep
  - AC field amplitude sweep
  - Drying over time
  - Gelling over time

![Graph showing AC susceptibility as a function of frequency]
Ordering due to Shear

- In a constant shear field, the particles will orient in the direction of the shear

![Diagram of ordering due to shear](image.png)
Coaxial Shear Magnetometry

- Measures AC susceptibility of ink as particles orient in the flow direction due to shear or DC field bias.
- Thin string is coated with dispersion.
- Simple geometry amenable to theoretical analysis and simulation. Interpret in terms of order parameter.