Sedimentation of Chiral Particles in a Shear Flow

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Outline

- Motivation
- Fundamentals of experiment
- Experimental procedures
- Mathematical description of particle motion
- Expected results and conclusions

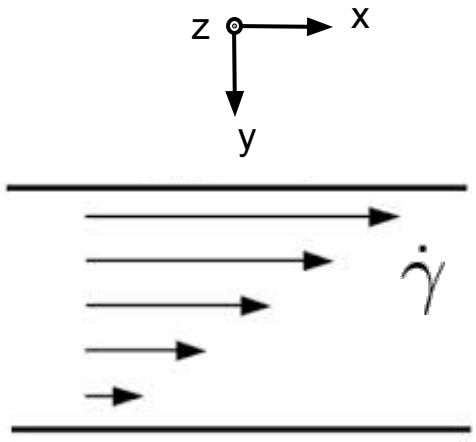
Motivation

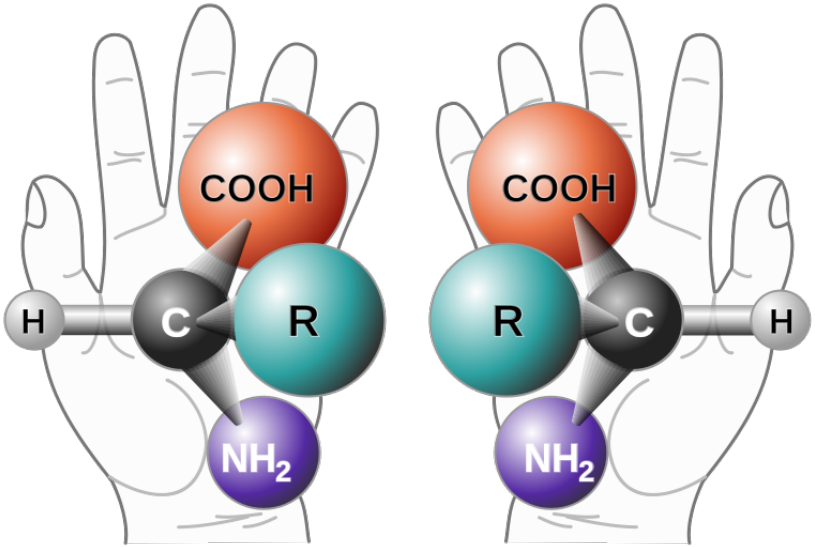
- To better understand how chiral objects behave in a shear flow
- To experimentally verify the paper by M. Makino and M. Doi

Masato Makino and Masao Doi, “Migration of twisted ribbon-like particles in simple shear flow,” *Phys. Fluids* **17**, 103605 (2005).

Background

- Chirality
- Shear Flow

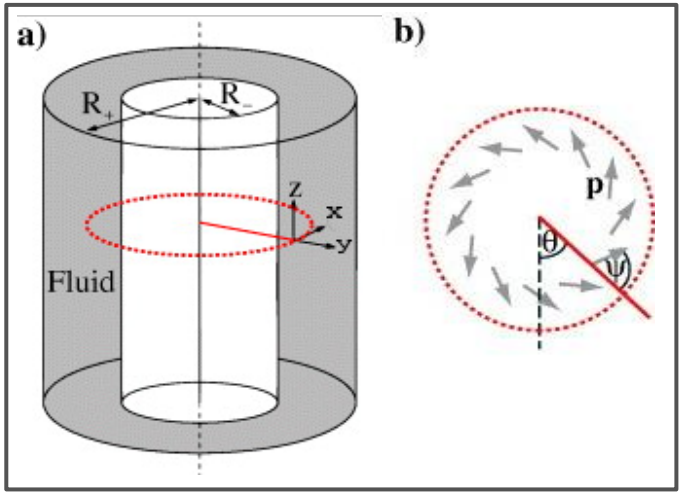


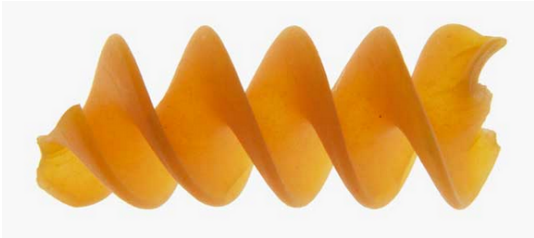


Courtesy of http://www.nai.arc.nasa.gov/
Courtesy of univ-paris-diderot.fr

Procedure

- Rheological separator to generate Taylor-Couette flow
- Highly viscous fluid (silicone oil) to get a large Péclet number
- Ribbon shaped chiral particles



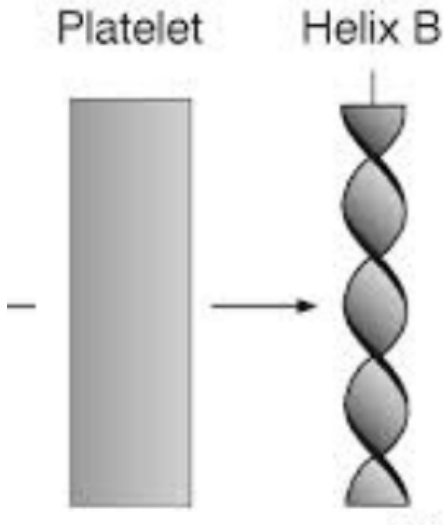


Courtesy of Discovery Science

Courtesy of IOP Science

Procedure

- Differently shaped chiral objects
  - Ribbons
  - Models of actual chiral particles
  - Non-chiral shapes
- Measurements
  - Z displacement
  - Shear flow



Masato Makino and Masao Doi, “Migration of twisted ribbon-like particles in simple shear flow,” *Phys. Fluids* **17**, 103605 (2005).
Picture courtesy of nature.com

Theory

Particle velocity: $\mathbf{V}(t) = \mathbf{V}_o + \tilde{\mathbf{g}}(t) : \mathbf{E} + \mathbf{V}_B(t)$

Mean migration velocity: $\langle \mathbf{V} \rangle = \langle \mathbf{V}_o \rangle + \langle \tilde{\mathbf{g}} \rangle : \mathbf{E}$

$$\langle \tilde{\mathbf{g}} \rangle = \sum_{ijk} \tilde{g}_{ijk} \langle \mathbf{u}_i \mathbf{u}_j \mathbf{u}_k \rangle$$

Physical characteristics of the particle

Theory

Makino's work shows that:

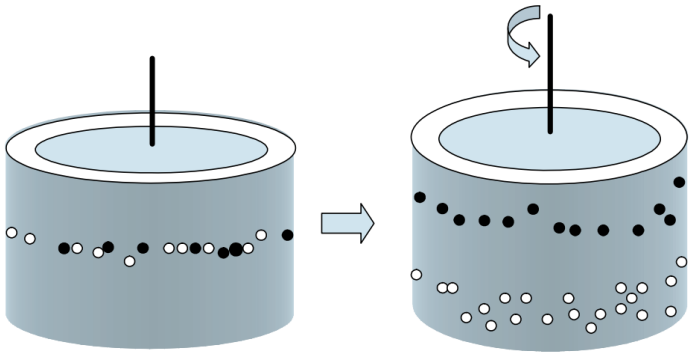
$$\langle V_z \rangle = \frac{1}{2}\tilde{g}\dot{\gamma}\left\langle u_{3x}^2 - u_{3y}^2 \right\rangle$$

This describes the motion due to the chiral shape.

Masato Makino and Masao Doi, "Migration of twisted ribbon-like particles in simple shear flow," *Phys. Fluids* **17**, 103605 (2005).

Expected Results

- Observe separation of the left and right handed particles
- Measure separation velocity for various shear rates
- Observe effect of particle shape on separation velocity



Courtesy of M.Makino [2]

Conclusion

- Validate theoretical models
- Explore properties of chiral particles in shear flow

References

[1] Masato Makino and Masao Doi, “Migration of twisted ribbon-like particles in simple shear flow,” *Phys. Fluids* **17**, 103605 (2005).

[2] Masato Makino, Leo Arai, and Masao Doi, “Shear Migration of Chiral Particle in Parallel-Disk,” *Jour. Phys. Soc. Japan* **77**(6), 064404 (2008).