Stirred, not shaken: Physicists gain more particle control

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Cornell physicists can now precisely control how particles in viscous liquids swirl, twirl and whirl. Think of coffee and adding cream—and gaining control of the particles in the cream. Understanding this concept could allow chemists, physicists and engineers to better detect molecules, control the mixture of nanoscale particles and enhance self-assembly in solutions.

Brian Leahy, Cornell doctoral student in the field of physics, presented "Revisiting Taylor Dispersion: Differential Enhancement of Rotational and Translational Diffusion Under Oscillatory Shear" at the American Physical Society meeting, Baltimore, March 18. His co-researchers include: Xiang Cheng, physics postdoctoral researcher; Itai Cohen, professor of physics; and Desmond Ong '11.

If you stir, diffusion—the random jostling of small particles from thermal energy—is enhanced. This enhancement is called Taylor dispersion. "Stirring transports the cream through the coffee and also enhances diffusion of the cream particles," said Leahy.

Using 3-D imaging microscopes, the physicists can now also see the orientation of oblong particles in a viscous fluid, providing the ability to measure the individual particle rotation rates for the first time.

"By adding shear and adjusting the flow, particles can not only be oriented but their rotational diffusion can also change," said Leahy.

In a fluid, oblong particles that are small enough can change their orientation due to rotational diffusion that arises when fluid molecules kick the particles in random directions. When the particle-laden fluid is rubbed between two oscillating plates, the oblong particles also rotate end-on-end in what is known as a Jeffery's orbit.

The researchers showed that the combination of rotational diffusion and Jeffery orbits has an effect that is bigger than the so-called "sum of the parts," so that the particles change their orientation faster than either mechanism alone.

While this is basic, physical research, understanding these concepts could lead to opportunities in other fields, said Cohen: improved self-assembly of specially shaped particles, designer materials, or producing liquids with directional dependence that flow easily.

Provided by Cornell University