American Physical Society
One Physics Ellipse
College Park, MD 20740-3844
www.aps.org

From *The 69th Meeting of The American Physical Society – Division of Fluid Dynamics*

Archimedes' Law of Buoyancy Turned Upside Down

Counterintuitive to Archimedes' famous law of buoyancy, researchers create a scenario in which bubbles sink while dense steel spheres rise within a complex fluid

EMBARGOED for release until 9 a.m. Eastern Time on November 21, 2016

For More Information:
AIP Media Line
media@aip.org
301-209-3090

Washington, D. C., November 21, 2016 -- A team at the University of Illinois at Urbana Champaign, exploring how air bubbles rise within a complex fluid, like those found while processing wet concrete, wondered if they could actually get them to *sink* instead by shaking the mixture in the right way.

During the 69th Annual Meeting of the American Physical Society's Division of Fluid Dynamics (DFD), being held November 20-22, in Portland, Oregon, Randy Ewoldt, an assistant professor who runs the Ewoldt Research Group in the Department of Mechanical Science and Engineering, and Jeremy Koch, a Ph.D. candidate, will present their work studying bubbles within complex fluids.

"Certain complex fluids are 'solid-like' when you don't push on them very hard," Koch explained. "One consequence of this is that they can trap air bubbles and hold them in place indefinitely."

This phenomenon begs the question: How do you get the air bubbles to move? "We can stir the fluid and move the bubbles around manually, or we can also put the fluid's container on a centrifuge and force the bubbles out," Koch said. "How does the centrifuge make this happen, and why do the bubbles move in the direction that they do? By understanding those questions, we'll be able to describe how to move the bubbles in other directions."

In terms of the basic concepts behind the group's work, one is acceleration, which requires force. "Shaking, a.k.a. 'accelerating,' a container of liquid creates a pressure force through the liquid," Ewoldt said. "The air bubbles inside are along for the ride and feel the same force as the liquid, but at a lower density so the force they feel is 'larger' than needed to match the liquid acceleration. When this force counteracts buoyancy, it can potentially move air bubbles downward within the surrounding fluid."

To put their theories to the test, the group introduced bubbles and solid spheres with diameters on the order of a few millimeters into fluids of various thicknesses. They used a rigid container to control the movement of the immersed particles.

Their results revealed the necessary conditions and fluid properties to prevent or produce the sinking motion of the bubbles and heavy particles – both with and against gravitational forces.

"Complex fluids are actually quite common in everyday life, from whipped cream to custard to pumpkin pie – and fresh concrete," Ewoldt said. "All of these materials can be sculpted into a shape (in a liquid state) and hold their shape even under gravity (as a solid)."

In other words, their work shows that rigid-body accelerations affect buoyancy and weight in the same way gravity does. “But you can’t simply accelerate a container indefinitely in one direction, so we focused on periodic motion: the container returns to its initial position and speed after a certain time interval,” Koch said.

They demonstrated a scenario in which bubbles sink while dense steel spheres rise, which is counterintuitive to common expectations of how buoyancy works. Intuition says bubbles will rise and steel objects will sink within the liquids, although they found the exact opposite was true. “Archimedes’ famous law of buoyance doesn’t consider accelerations or ‘complex’ fluids,” Ewoldt said.

This made the group wonder: Has it really taken humans this long to reveal this basic behavior? And, if so, what else are we missing?

There are countless applications for suspensions within real-world fluids and, thanks to this work, more information is now available to help make better decisions. When the motion involved is periodic, does it mean the effect is cancelled out? “If viscosity is constant, the answer is yes,” Ewoldt said. “But if viscosity isn’t constant -- if it changes the more you flow the fluid—the answer is no.”

Time series of an air bubble forced to sink within a complex fluid. (Credit: University of Illinois at Urbana Champaign.)

####
Abstract: A21.00002 : "Sinking Bubbles," by Jeremy Koch and Randy Ewoldt is at 8:13-8:26am PST, November 20, 2016 in Room D139-140

For more information about the APS DFD 2016 meeting, visit: http://apsdfd2016pdx.org/

MORE MEETING INFORMATION

USEFUL LINKS
Main meeting website: http://apsdfd2016pdx.org/
Technical program: http://meetings.aps.org/Meeting/DFD16/Content/3199
Meeting/Hotel site: http://apsdfd2016pdx.org/?page_id=30
Press Room: http://www.aps.org/newsroom/index.cfm

PRESS REGISTRATION
We will grant free registration to credentialed journalists and professional freelance journalists. If you are a reporter and would like to attend, contact Julia Majors (jmajors@aip.org, 301-209-3103) who can also help with setting up interviews and obtaining images, sound clips, or background information.

LIVE MEDIA WEBCAST
A press briefing featuring a selection of newsworthy research will be webcast live from the conference on Monday, November 21st. The first briefing at 2:00pm (EST) is about the forensic analysis of blood spatter and how changing the position of your

fingers can help you swim faster. The second one at 4:00pm (EST) is about cat's Velcro-like tongues and bubbles. More information can be found at the following link: https://www.aps.org/units/dfd/pressroom/

ABOUT The DIVISION OF FLUID DYNAMICS OF THE AMERICAN PHYSICAL SOCIETY
The Division of Fluid Dynamics of the American Physical Society exists for the advancement and diffusion of knowledge of the physics of fluids with special emphasis on the dynamical theories of the liquid, plastic and gaseous states of matter under all conditions of temperature and pressure. https://www.aps.org/units/dfd/

####