Video: The strange way fluids slosh on the International Space Station

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The next time you pour yourself a glass of water, pause before you drink it. First, swirl the clear liquid around the glass. Gently slosh it back and forth. Tap the glass on the tabletop, and watch the patterns that form on the surface.

Now imagine the same exercise … in zero gravity. Would the waves and ripples look the same? Would the liquid slosh more, or less? Faster, or slower?

NASA engineers spend a surprising amount of time asking themselves these same questions.

Their interest centers not on water glasses, but rather on fuel tanks. NASA's most powerful rockets use liquid fuel, and when these rockets blast off, the propellants slosh around.

Scientists have a good idea how liquids slosh in normal Earth gravity where the weight and viscosity of the liquid rule its dynamics. Deep space is different, however. Weightless propellants are guided by surface tension and capillary effects. Far from Earth, they could slosh and froth in unexpected ways.

"Modern computer models try to predict how liquid moves inside a propellant tank," says Brandon Marsell of NASA's Fluid Group at the Kennedy Space Center. "Most of the models we have were validated under 1 g conditions on Earth. None have been validated in

microgravity."

Enter the SPHERES-Slosh experiment.

"The International Space Station provides the perfect environment to conduct liquid behavior studies in microgravity," says the principal investigator, Paul Schallhorn also at Kennedy. "So we have designed an experiment that simulates how rocket fuels move around inside their tanks."

Built by Professor Dan Kirk and colleagues at the Florida Institute of Technology, SPHERES-Slosh is, essentially, a fluid chamber grappled by a pair of bowling ball-sized robots. The two SPHERES (a product of the Space Systems Laboratory at MIT) were already onboard the space station when the Slosh chamber arrived in February 2014. Together, the robots move the chamber back and forth to mimic common spacecraft maneuvers such as the "BBQ roll", attitude adjustments, and engine shut-downs.

In 2014, astronauts supervised the robots as they made three test runs using chambers 20% and 40% filled with fluid—much like a partially-spent fuel tank.

"We use water mixed with a bit of green food coloring," says Schallhorn.

Why water? "For one thing, it is a safe fluid for the space station. Water is on the approved list of fluids we can send to the station," he explains. "Also, its viscosity is similar to hydrazine, a propellant used by satellites; and its density is similar to liquid oxygen, an important cryogenic propellant."

During the experiments, which can last as long as six hours, cameras, gyros and accelerometers record the motions of the water.

"We are getting great data," says Marsell. "So far," he says, "our computer models on Earth have done a good job predicting wave motions inside the chamber."

But there is a mystery….

"It has to do with bubbles," says Schallhorn. "The way bubbles form and interact inside the chamber is surprising—and not predicted by our models. We were taken off guard with what we saw in the data."

The bubbling and frothing of shaken fuels is cutting-edge research in fluid dynamics, and SPHERE-Slosh is showing that it may be very important.

Jacob Roth of the Fluids Group at KSC adds, "this is something we plan to investigate further. Who knows? It might just shake up our understanding of fluids in space."

Provided by NASA