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Bursting with excitement – A look at bubbles and fluids in space

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Roscosmos cosmonaut Oleg Kononenko conducts a sample exchange for the OASIS investigation. OASIS studies the unique behavior of liquid crystals in microgravity, including their overall motion and the merging of crystal layers known as smectic islands. Credit: NASA

Watching a bubble float effortlessly through the International Space

Station may be mesmerizing and beautiful to witness, but that same bubble is also teaching researchers about how fluids behave differently in microgravity than they do on Earth. The near-weightless conditions aboard the station allow researchers to observe and control a wide variety of fluids in ways that are not possible on Earth, primarily due to surface tension dynamics and the lack of buoyancy and sedimentation within fluids in the low-gravity environment.

Understanding how fluids react in these conditions could lead to improved designs on fuel tanks, water systems and other fluid-based systems for space travel, as well as back on Earth.

Many investigations aboard the orbiting laboratory focus on fluid physics including the motion of liquids or the formation of bubbles. As on Earth, the formation of a bubble is sometimes a welcomed addition, but could also be an indication that something has gone wrong and must be reworked. Technology, investigations, and even tasks as simple as drinking water must take bubbles into consideration to be adapted to be functional in a microgravity environment.

Here are several investigations that use bubbles or fluid physics to their advantage.

- The Observation Analysis of Smectic Islands in Space (OASIS) investigation studied the unique behavior of liquid crystals in microgravity, noting the way these crystals act as both a solid and a liquid. Freely suspended crystal bubbles in microgravity represent nearly ideal fluid systems that are physically and chemically the same for the study of liquids in motion. Understanding how these crystals behave in space could lead to improvements to space-helmet micro-displays, as well as higher-quality screen displays on devices that use liquid crystal displays (LCDs).

- The Capillary Flow Experiment (CFE) sought to solve the problem of transferring fluid from one container to another in space. Without gravity, liquids don't flow the same way they do on Earth, nor do they collect at the bottom of a container the way you would expect them to in gravity. Research found that although controlling the flow of fluids is difficult in space, capillary forces, or the ability for a fluid to flow through a narrow tube without the assistance of gravity, are still present. Capillary Flow Experiment 2 is expanding the fluid physics research conducted during CFE by exploring liquid's ability to spread across a surface in microgravity. Results from the Capillary Flow Experiments could lead to more efficient fluid systems aboard future spacecraft, and a better understanding of capillary forces present within porous materials such as sand, soil, wicks and sponges.
- Researchers used the data collected during the Constrained Vapor Bubble investigation to gain a better understanding of the physics of evaporation and condensation and how they affect cooling processes. The results from this investigation aided in the development of simple models of bubble formation, which could help develop more efficient microelectronic cooling systems.
- The Eli Lilly Hard to Wet Surfaces investigation studies a material's ability to dissolve in water while in microgravity, and may shed light on why drugs seem less effective in space compared to on Earth. Results from this investigation could help improve the design of tablets that dissolve in the body and lead to more efficient drug delivery on Earth and in space.
- The Nucleate Pool Boiling Experiment used microgravity to observe bubble growth from a heated surface and the subsequent detachment of the bubble to a cooler surrounding liquid, and the process by which bubbles can transfer heat through fluid flow. Information gathered during this investigation could lead to optimal equipment used to transfer heat in harsh environments

such as the deep ocean, extreme cold and high altitudes.

- Two-Phase Flow investigates the heat transfer characteristics of how liquids flow when boiling in microgravity environments. Heat is removed in the boiling process normally by turning liquid into vapor at the heated surface, and that vapor returns to a liquid by way of condensation which continues to cycle and make a cooling system. Liquid and bubble behave much differently in space than on Earth, and this research may help to provide a fundamental understanding of the behaviors of bubble formation, liquid vapor flow in a tube and how heat transfers in cooling systems.

Designed to host a wide range of investigations, there are multiple facilities aboard the station for conducting fluid physics investigations. The Fluids Integrated Rack, the Fluid Science Laboratory, and the Fluid Physics Experiment Facility all host investigations in areas such as colloids, bubbles, wetting, capillary action and phase changes.

NASA astronaut Kate Rubins sets up the Eli Lilly - Hard to Wet Surfaces Sample Module by injecting buffer solutions into the sample vials then mixing all six sample vials inside the Sample Module. This investigation studies how certain materials used in the pharmaceutical industry dissolve in water while in microgravity and could lead to improved tablet design. Credit: NASA

NASA astronaut Karen Nyberg watches a water bubble float freely between her and the camera, showing her image refracted in the droplet. Credit: NASA

Provided by NASA