# Top Videos Include Evaporating Drops and Ocean Bubbles

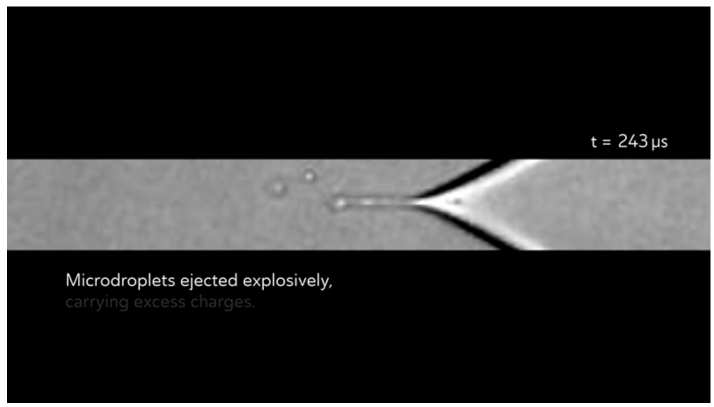
**Prize-winning videos cover the range from microscopic droplets to global climate.**

By **David Ehrenstein**

The APS Division of Fluid Dynamics (DFD) has announced the 2024 winners of its annual **Gallery of Fluid Motion** video and poster contest. The videos below received the Milton van Dyke Award, which recognizes both videos and posters. **A traveling exhibit** of past winners is currently **on display in Salt Lake City**.

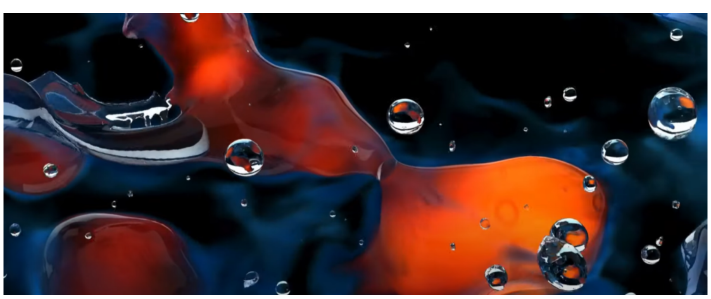
## Fireworks in a Petri Dish

In 2015, then-graduate-student Dan Daniel observed a strange behavior in water drops evaporating on an oily surface: From above, each drop appeared to regularly switch from a circle to an ellipse and then back to a circle. At the time, Daniel had no way to study these shape oscillations in detail, but now, as a professor at the King Abdullah University of Science and Technology (KAUST), Saudi Arabia, he and his colleagues have reexamined the phenomenon using several technologies including a high-speed microscope. Their observations showed that the oscillations arise from charge-induced ejections of fluid from the drop surface.



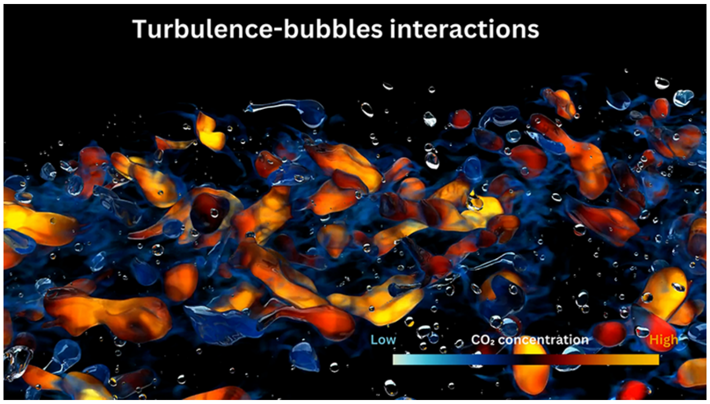

Unexpected shape oscillations in evaporating drops are explained.
**Credit: M. Lin/KAUST**

The researchers realized the importance of using a plastic pipette for drop placement, as this method imparts a charge to the drop. As the drop evaporates and shrinks, the charges on its surface become closer, and their repulsive energy grows. Eventually, this energy becomes so great that the drop elongates and shoots out a tiny, charged water jet at one end of the oval shape. The jet breaks up into a spray of microdroplets, after which the drop returns to circular shrinking. Later, the repulsive energy becomes too great again, resulting in another elongation and spray. KAUST team member Marcus Lin recalls the team's initial surprise at witnessing this behavior. "We ended up replaying the first recording over and over in disbelief—it was like seeing a mini fireworks display."



Credit: S. Di Giorgio/Institute of Marine Engineering (INM-CNR)

Lin says the phenomenon is part of the team's research into interfacial phenomena. The researchers hope that the drop studies will lead to applications such as efficient aerosol



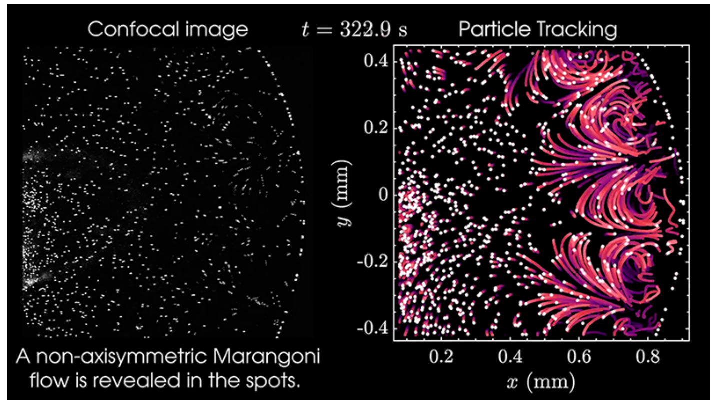

Simulations show the effect of bubble-distorting turbulence on the absorption of $CO_2$ in the ocean.
**Credit: S. Di Giorgio/Institute of Marine Engineering (INM-CNR)**

generation, improved inkjet printing, and new microscale materials fabrication techniques.

### Miniscule Bubbles Influence Global Climate

Understanding the global carbon cycle is essential for modeling climate change. Researchers estimate that 26% of $CO_2$ sent into the atmosphere is absorbed by the ocean, but there is a lack of detailed information on exactly how this absorption takes place. So Simone Di Giorgio of the Italian National Research Council's Institute of Marine Engineering and his colleagues performed high-precision numerical modeling of one key component of this process: $CO_2$ absorption through air bubbles produced when ocean waves break.

The researchers simulated a flowing channel of water initially containing an array of spherical air bubbles. In the simulation, the $CO_2$ in these bubbles can be absorbed into the water, but the rate of this absorption is limited by the bubble surface area. As the flow progresses, the bubbles become highly distorted by turbulence, which increases the surface area of the gas–water interface and thus the rate of $CO_2$ absorption. The simulation provided an unprecedented level of detail, showing processes such as two-bubble mergers and single-bubble pinch offs. Di Giorgio says that the simulations reveal the important effects of turbulence and of other factors on the rate of $CO_2$ absorption. "Ultimately, we aim to bridge the gap between theoretical research and practical applications in environmental science and engineering," Di Giorgio says.




Surface-tension effects explain eddy formation at the edges of a drop containing a mixture of water and hexanediol.
**Credit: P. Dekker/University of Twente**

### Explaining a Surprising Asymmetry

Christian Diddens of the University of Twente, Netherlands, and his colleagues also discovered a mysterious behavior in stationary, evaporating liquid drops. In 2017 graduate student Yaxing Li noticed eddies forming at the edges of drops made from a mixture of water and 1,2-hexanediol—a common inkjet ink additive. The flow in liquid drops is heavily influenced by spatial variations in the surface tension, but in this case surface tension was expected to have a fixed value in the outer regions of the drop. "Without any spatial gradients in the surface tension, droplets usually show a rather slow, radially outward, symmetric flow," Diddens says.

Through experiments, theory, and simulations, the team determined that in fact there was a slight rise in surface tension near the edge, just enough to explain the eddies. The researchers have a long-term collaboration with Canon Production Printing to develop inks with desired drying properties, Diddens says.

David Ehrenstein is a Senior Editor for ***Physics Magazine***.