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The Physics of Fizziness

Droplets are ejected when bubbles burst at a liquid's surface. The cause? Bubble shape, capillary waves, gravity and liquid properties all combine to form an intricate prelude to bursting-bubble aerosols

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EMBARGOED until 4:00 p.m. PT on Sunday, November 23, 2014

For More Information:
Jason Socrates Bardi, AIP
jbardi@aip.org
240-535-4954
@jasonbardi

WASHINGTON, D.C., November 23, 2014 -- If you've ever raised a glass of champagne in celebration, you may have noticed tiny bubbles bursting on its surface. But did you know this little event, which is commonly seen in much greater scale on the ocean's surface, involves a fascinating facet of physics?

When bubbles burst the thin liquid film at the surface, the "bubble cap" that separates the bubble from the atmosphere disintegrates and the resulting opened cavity collapses. This, in turn, causes an upward jet that releases a few tiny droplets as it breaks up.

During the American Physical Society's Division of Fluid Dynamics (DFD) Meeting, Nov. 23-25, 2014, in San Francisco, Calif., Thomas Seon and Elisabeth Ghabache, researchers working for CNRS & UPMC at the Institute d' Alembert, in France, and their colleagues will describe the intricate roles of bubble shape, capillary waves, gravity and liquid properties in bubble-bursting jet dynamics, which form the prelude to aerosols -- including unexpected results which should help pave the road to the control of bubble-bursting aerosols and may even find more novel applications such as the fine-tuning of aroma diffusion in champagne or wine.

"Bubble-bursting drops are ubiquitous in everyday life and provoke the pleasant fizzy sensation when savoring a glass of sparkling wine, champagne or any soda," said Seon. "But on a larger scale, they constitute sea spray aerosols or sea mist, which plays a huge role in the chemical exchanges between ocean and atmosphere."

During the past 60 years, while numerous laboratory studies have documented bubble-bursting drops' properties such as their ejection speed, maximum height or size, a comprehensive picture of the mechanisms at play is still lacking. "In particular, the sequence of violent events preluding jet formation and the roles of liquid properties remain elusive," explained Seon.

So what exactly are the basic underlying capillary fluidic effects explored by Seon and colleagues? Their work is based on what happens when the film separating the bubble from the atmosphere (surface) drains and bursts—leaving an unstable opened cavity. This cavity is millimeter-sized, so the restoring force, which tends to return this hole to a flat equilibrium, is capillary—not gravity—driven.

“Capillary waves propagate along this cavity,” pointed out Seon. “And the collapsing waves give rise to a high-speed vertical jet that shoots out above the free surface (as you can see in the top sequence of Figure 1). The jet then fragments into droplets, generating an aerosol of one to 10 droplets.”

Seon, Ghabache and colleagues demonstrated that droplet ejection depends not only on the bubble geometry, but also, critically, on the liquid properties. “We characterize the relation between all of these parameters,” he said. “One of the most counterintuitive results is that bubbles bursting in more viscous [thicker] liquids produce smaller and faster droplets.”

The researchers’ unexpected results should help pave the road to the control of bubble-bursting aerosols and may even find more novel applications such as the fine-tuning of aroma diffusion in champagne or wine. “By changing the viscosity of champagne slightly, we could generate an aerosols-optimizing-the-diffusion aroma,” Seon noted.

The presentation, “On the Physics of Fizziness: How liquid properties control bursting bubble aerosol production?” is at 4:45 p.m. PT on Sunday, Nov. 23, 2014 in the Moscone West Convention Center, Room 3006. ABSTRACT: http://meetings.aps.org/Meeting/DFD14/Session/E4.4

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MEETING INFORMATION
The 67th Annual Division of Fluid Dynamics Meeting will be held at Moscone West Convention Center in San Francisco, Calif. from Nov. 23-25, 2014. More meeting information: http://apsdfd2014.stanford.edu/

REGISTERING AS PRESS
Any journalist, full-time or freelance, may attend the conference free of charge. Please email: jbardi@aip.org and dfdmedia@aps.org and include "DFD Press Registration" in the subject line.

ONSIGHT AND ONLINE PRESS ROOMS
Workspace will be provided on-site during the meeting. The week before the meeting, news, videos and graphics will be made available on the Virtual Press Room: http://www.aps.org/units/dfd/pressroom

LIVE MEDIA EVENT
A press briefing featuring a selection of newsworthy research talks will be webcast live from the conference at 1:00pm PST on Monday, November 24 in room Foothill F of the San Francisco Marriott Marquis. For more information, email jbardi@aip.org

ABOUT THE APS DIVISION OF FLUID DYNAMICS
The Division of Fluid Dynamics (DFD) of the American Physical Society (APS) 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. DFD Website: http://www.aps.org/units/dfd/index.cfm