

Bouncing liquid surface can make bubbles do a stop-start dance

Enlarge / Moving bubbles.

reader comments

20 with 17 posters participating

Share this story

Sometimes life just isn't fair. If you play with fluids, you get to use cool camera systems, and every paper fluid researchers write comes with a fancy video of a fluid performing unnatural acts. Then, when you ask about applications, the researchers point to ink jet printers.

This should actually be taken as a warning. If you force a scientist to come up with an application, they will invent the ink jet printer as a form of long-lasting revenge. So, please, don't ask what bouncing *superwalker* bubbles might be useful for.

Bubble, bubble, toil and... inkjet?

Way back in the '70s, scientists discovered that if you take a droplet of oil and place it on the surface of an oil bath, it will bounce up and down as long as the surface of the bath is vibrating. About 10 years ago, scientists went a step further and showed that if you chose the vibrational frequency just right, then the droplet would move around the surface. Scientists referred to these perambulatory droplets as

walkers—perhaps in a tribute to the fragility of walkers in Star Wars.

The essential idea is that if the liquid bath is subject to vibration from below (the researchers use the woofer from a speaker), then a standing wave pattern will form on the top. (An example is shown in the embedded video below.) Under the right circumstances, droplets will bounce from valley to valley in the standing wave pattern, because they cannot manage to hit and stabilize at the center of a valley.

[embedded content]

Standing waves in a bowl of water (Tom Czarnota).

The motion is also regular: in one mode, the drop will bounce from one valley to the next, while in the next mode it will skip and only land in every second valley. However, this also limits the size of the droplet and the speed of the walker. Essentially, the frequency of vibration and the spacing of the valleys vary in a fixed ratio, which limits the range of speeds of the walker as well.

Giant bubbles wandering around

This month, a new paper demonstrates a class of jumbo superwalkers that are two to three times bigger than normal and move three or four times faster. These big, bouncing walkers can also be made to stop in place and start moving again. In other words, scientists are starting to get some control over the motion.

How is this achieved? Essentially, by vibrating the bath surface at two frequencies instead of one. This creates a more complex surface, one that causes the droplets to leap from valley to valley; thanks to the two frequencies, these valleys are separated by larger distances. The movement of the droplets is controlled (to some extent) by the phase between the two sound waves, which changes the standing wave pattern.

At the right phase, the bubbles just bounce up and down in place. But changing the phase means the droplets can be accelerated away again. You can even cause the bubbles to be reabsorbed by choosing the phase correctly.

Sample videos of droplet motion. I recommend the first three: Chasers_7, Promenade_SW_2, and Stop_and_go_1, which show examples of the points I've discussed in the story.

Surprisingly, the amplitude of the sound waves does not have direct influence on the speed. Instead it kind of sets the regime. At low amplitude, the bubbles only bounce in place, then as the amplitude increases, the bubbles switch to the walking regime, and finally the superwalking regime. Within each of these regimes, the speed is controlled by the relative phase between the two frequencies.

Serious fun

Now, at the risk of causing another ink jet printer event, what is this useful for? Personally, I think this is just a cool demonstration of the power of fluid dynamics and a fun experiment. But, if I were trying to convince people to give me money, I would discuss microfluidics. Microfluidics is the idea that we can do biochemistry much more efficiently on a chip by shoveling little bubbles of reactants around in tiny channels. The demonstrations are always really awesome, but the chips never last because the channels clog up.

This research offers the possibility of microfluidics without the channels. Each bubble contains its own set of reactants, which can be coalesced by driving the bubbles together. Heating could be applied by infrared light sources (lasers ftw again), while cooling could be passive. And, when you are done, let the bubbles return to the bath from whence they came. Of course, this is not on a chip and, therefore, 100% less cool. But I will take a working device over cool once every decade.

Physical Review Letters, 2019, DOI:
10.1103/PhysRevLett.123.024503 (About DOIs)

<https://arstechnica.com/?p=1540737>