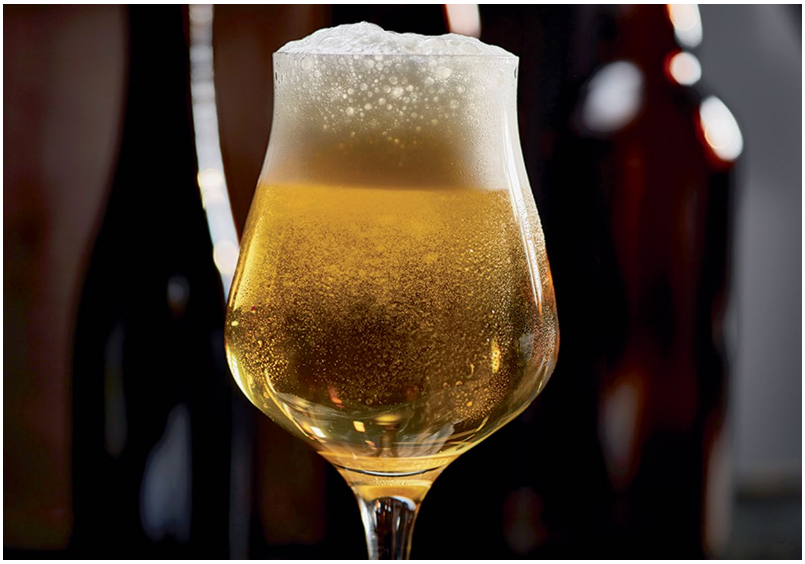
https://doi.org/10.1038/s42254-023-00579-y

The physics of fizz

A glass of your preferred carbonated drink — whether beer, champagne or soda — holds some fascinating physics. This month, we share some of our favourite bubbly phenomena.



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Pulling the perfect pint of beer requires skill and science, especially to achieve the precise foam-to-liquid ratio as determined by beer connoisseurs. For a pint of Guinness, the head should be 18–20 mm, or reaching to just above the harp on a Guinness glass. Traditionally, to achieve this ratio, bartenders used two kegs. First, the beer would be poured from a high-pressure keg, which would create a foamy head. Once the bubbles settled, a low-pressure keg would be used to fill the glass – this less-bubbly beer would fall to the bottom of the glass, pushing up the foamy head to the right level (the widest part of the glass). In the 1950s, as the popularity of Guinness was growing beyond Ireland, the company wanted to simplify the process, and employed a mathematician, Michael Ash, to help. Ash introduced the idea of adding nitrogen to the carbonated drink. Whereas CO_2 creates large bubbles that rise up and try to escape from the drink, N_2 creates tiny bubbles that lead to a foamy texture. As N_2 is insoluble in water, the foam is also much more stable[1]. Using a combination of the two gases (70% N_2, 30% CO_2) leads to a beer with a stable, foamy head, which also looks pretty as it is poured – the small N_2 bubbles fall, while the large CO_2 bubbles rise, creating a cascading effect.

What about drinking beer from a bottle? Typically this won't come with a foamy head – unless your friend plays a prank on you, and sharply hits the top of your bottle with theirs, leading to a foamy explosion. A paper in *Physical Review Letters* sheds light on the physics behind this phenomenon[2]. The sudden impact sends a compression wave down through the bottle that bounces up and down the bottle, breaking up the bubbles in the liquid into smaller fragments. This leads to a sudden increase in bubble surface area that increases CO_2 diffusion out of the liquid – which leads to more bubbles forming. Buoyancy forces the increasing numbers of bubbles to rise to the top, which introduces them to even more CO_2. This self-accelerating process continues until the foam spills out of the top of the bottle.

Shaking a bottle or a can of a fizzy drink can lead to a similar explosion of foam and liquid when you open it. Shaking allows bubbles to nucleate, and when the can is opened, they rapidly grow, pushing liquid out of the way (and over your shirt front). A common belief is that if a can has been rattling around your bag for a while, you can lightly tap the can to stop this happening. There's at least one possible mechanism behind this procedure, namely that tapping the can allows bubbles to move to the top of the can before it's opened, so that when they grow they have less liquid to displace. However, a 2019 preprint[3] reports a randomized controlled trial of opening ~1,000 beer cans, which were either shaken or unshaken, and tapped or untapped. That study failed to find any significant effect of tapping a shaken can, although the authors note that some of the proteins in beer may hinder bubbles from rising to the surface, so their results are not necessarily applicable to sodas.

> **"Whereas CO_2 creates large bubbles that rise up and try to escape from the drink, N_2 creates tiny bubbles that lead to a foamy texture."**

Besides giving a drink its 'texture', bubbles can also contribute to its smell. In a glass of champagne, bubbles that nucleate at the glass walls drag various surfactants to the surface as they rise. As a result, the surfactant concentration increases at the champagne–air interface at the top of the glass. High-speed imaging shows that as bubbles burst at the surface, they produce a jet of liquid that breaks up into tiny aerosol droplets. Ultrahigh-resolution mass spectroscopy of the aerosols shows that they contain a variety of aroma precursors, which helps explain why champagne and sparkling wines have a distinctive aroma profile compared to other wines[4].

At *Nature Reviews Physics* we always enjoy thinking about the physics of the everyday. Let us know your favourite fun facts – by email, Twitter or next time we meet at a conference.

References

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