

Bubbles rising in line: champagne, lager, cider

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Abstract

Various drinks contain vertical lines of rising bubbles. They seem to be stable in glasses of champagne or lager unless two lines are so close together that they interfere with each other, but in cider the bubbles sometimes move out of line on the way to the surface even when they are small enough that a single one would rise vertically.

It is already known that in a pure liquid the lines are unstable, because the wake of a rising bubble contains rising liquid, so the vortex rings in it are horizontal. A second bubble rising off the centreline will make those rings slope up on one side of its own wake and down on the other, revealing the existence of a lift force on that bubble pushing it further out of line, in the same way that the vortices trailing behind an aircraft wing reveal the existence of the lift force keeping it in the air.

It is also known that in a surfactant solution the lines are stabilised, because the first bubble has a higher concentration of surfactant on the centre-line of its wake than further out, which makes the surface tension lower there, and it is therefore energetically favourable for the second bubble to follow the first. Hence the second bubble may move out of line in a sufficiently dilute surfactant solution, but remain in line in a more concentrated solution. This conclusion is unaltered if a bubble follows behind several previous ones, though the critical concentration for neutral stability will change.

All that theory is for bubbles whose size remains the same as they rise. Real bubbly drinks are usually supersaturated solutions of carbon dioxide, which makes the bubbles grow as they rise. Each growing bubble then acts like a point source of liquid, and any two of them repel each other. If a lower bubble is slightly out of line with those above it, it will tend to move further out of line. That effect increases the amount of surfactant needed to stabilise the line.