

The Latte Effect

Many people have heard the “Latte Effect” 500 times or more and have never noticed it. It requires a beverage with very small bubbles which can be stirred into the liquid. A dramatic pitch change occurs as the bubbles rise to the surface. It also happens in some households where water from the tap becomes milky as myriads of tiny bubbles form. These bubbles form because the water is saturated with air under pressure and the pressure is released as the water emerges from the tap. Less air is soluble at lower pressure and the excess air comes out of the liquid as bubbles.

A well made cafe latte is ideal. The sonogram in the figure extends over about 20 seconds, and the vertical axis runs from 0 Hz to 1500 Hz. A spoon is repeatedly tapped on the bottom of a coffee cup after the beverage is vigorously stirred. A frequency can be seen rising from around 500 Hz to around 1300 Hz. The corresponding audio frequencies are blatantly obvious once you listen for them. This phenomenon has never been systematically studied, although there are a couple of papers in the literature concerning this and related effects. The effect is undoubtedly due in part to reduced sound velocity, and the resulting lower resonant frequency of a compression mode of the column of liquid, due to a drastic decrease in bulk modulus (inverse of compressibility), owing to a high concentration of bubbles. The speed of sound in a liquid goes as

$$c = \sqrt{\frac{K}{\rho}}$$

where K is the bulk modulus and ρ is the density of the liquid. Water is essentially incompressible compared to air. The mixture of water and many tiny bubbles of air gradually increases its bulk modulus toward that of pure water as the bubbles leave, rising to the surface. The resonance frequency of the compressible liquid rises. However, the precise mechanism for the sound production has not been worked out and is probably rather complicated to get correct. The nonuniform nature of the liquid (more bubbles near the top as they rise) probably needs to be considered.