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Singing glasses, musical mugs

Everybody knows how to make a wineglass sing. Just run a wet finger around the rim of a clean glass. It is a well known after-dinner trick, but as physicists we may ask: what exactly makes the glass squeak, and what mode of vibration are we inducing? Let's first look at the mechanism. It is the same 'stick-slip' motion that is used to play the violin, or the cello and the bass. Without probably realising it, when we run our finger around the rim of the glass we are making use of the fact that dynamic friction is lower than static friction. Whenever our finger sticks for a split second, the glass is slightly stretched, but once our finger gets moving again, the glass surface slides back easily, returning to its original state.

Now what kind of vibration are we inducing in the glass? Given the relatively loud noise that we can produce using this trick, we suspect that it must be a transverse vibration, so that the side of the glass transmits the noise to the surrounding air. Moreover, we guess that we are exciting the simplest possible vibrational mode: the fundamental.

Indeed, if we tap the glass at its side using a spoon, we notice that the frequency – or pitch – of the sound produced is the same as the one we get by running our finger around the rim. This strongly suggests that we are exciting the fundamental in both cases. In other words: if we tap, say, the North side of the glass, we should expect antinodes also at the South, East and West sides of the glass, and nodes at the four positions just in between.

There is an elegant way to prove us right. Just replace the glass by a mug that has a handle. If there is a choice, take a thin-walled mug made of good-quality pottery. Put it in front of you on the table with the handle towards you, pointing South, so to speak. Now take a spoon and tap. If you tap at the opposite side (North), or East or West, you produce a tone that is distinctly lower than if you tap at positions in between. This confirms that it is the fundamental vibration mode that we are exciting: it is the handle's extra mass that makes the frequency lower if it is positioned on an antinode. Look at it as a simple variation on the harmonic oscillator theme, for which we remember the frequency to be determined by $\sqrt{(k/m)}$, with k the force constant and m the mass.

Further evidence for the fact that we are dealing with the fundamental is obtained by holding the mug by the handle and repeating the experiment. If we tap the mug at the side opposite from the handle, the (lower) tone that we get is distinctly more damped than the one we get if we tap in between (the higher tone).

So, should your next formal dinner turn out a bit dull, physics may come to the rescue and bring some unexpected entertainment. Provided, of course, that there is wine. And coffee cups with a reasonable quality... ■