

The Gravitational Wave Chirp Bottle



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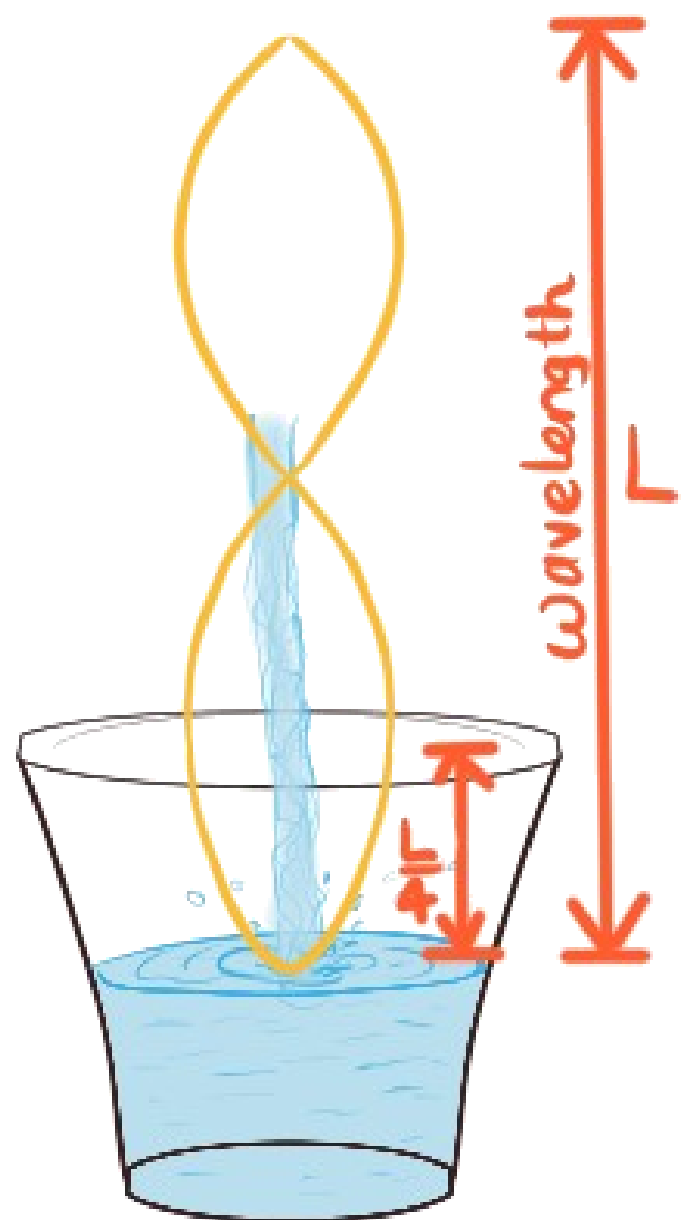
What's common between the following?

The curious sound when you fill a bottle...

and

The gravitational waves emitted by merging black holes...

All kinds of sounds are generated when water drips into any vessel

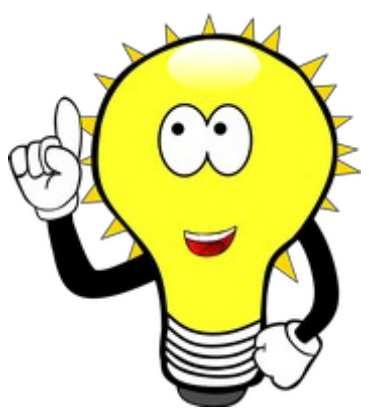


But the **loudest** sound is the one that **resonates** with the standing column of air above the water surface

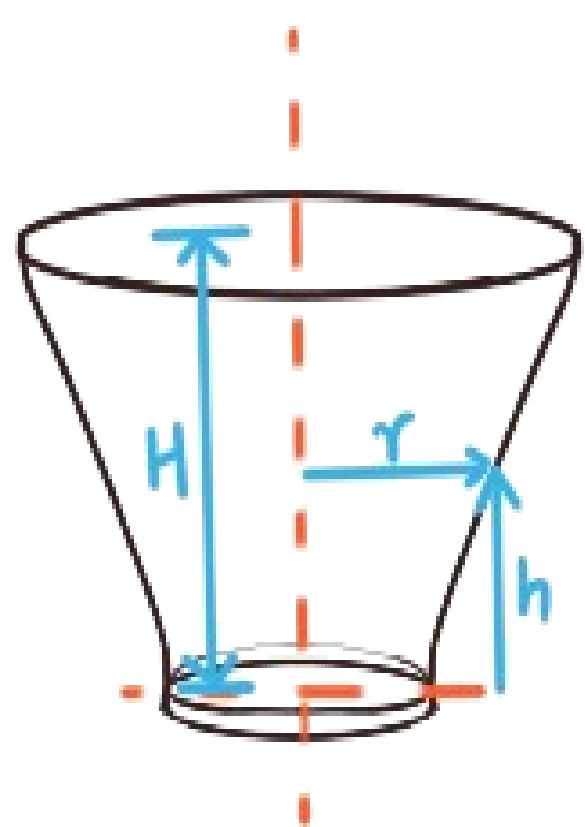
It has a wavelength 4 times the height of the air column

As the vessel fills up

- The height of the air column decreases
- So the wavelength of sound decreases
- frequency $\propto 1 / \text{wavelength}$



The frequency of **sound** increases with time as the bottle gets filled!



The exact behaviour of the frequency with time depends on the shape of the bottle i.e. on radius r vs height h

If the bottle's radius goes with height as

$$r \propto (H-h)^{0.9}$$

(a slightly rounded cone, like this one),

the emitted **sound** matches the **gravitational waves** emitted by merging black holes!

Gravitational waves take energy away from black holes orbiting each other

This shrinks their orbit with time until, eventually, they lose enough energy to collide and merge

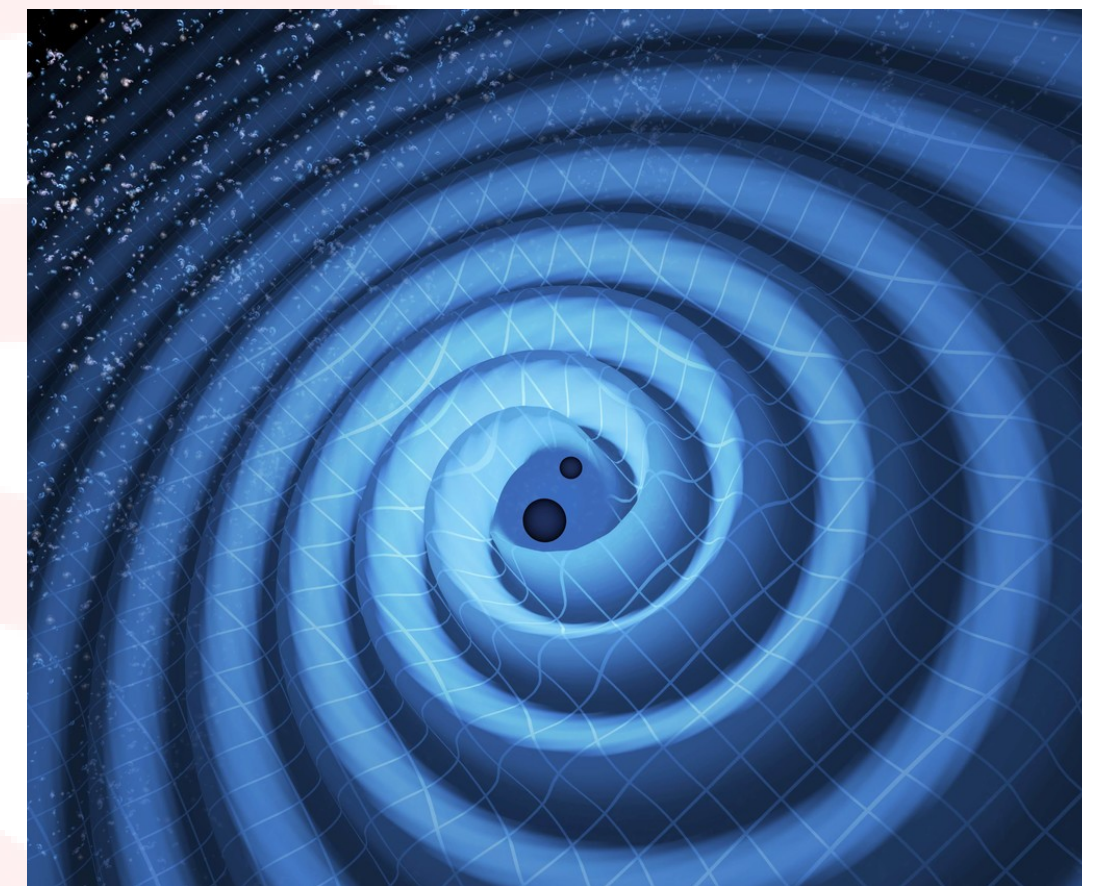
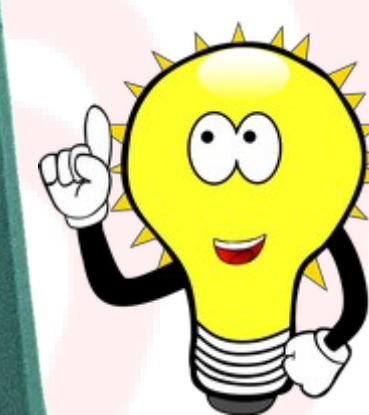


Image credit: LIGO/T. Pyle

The way gravity works, *smaller orbits are faster*

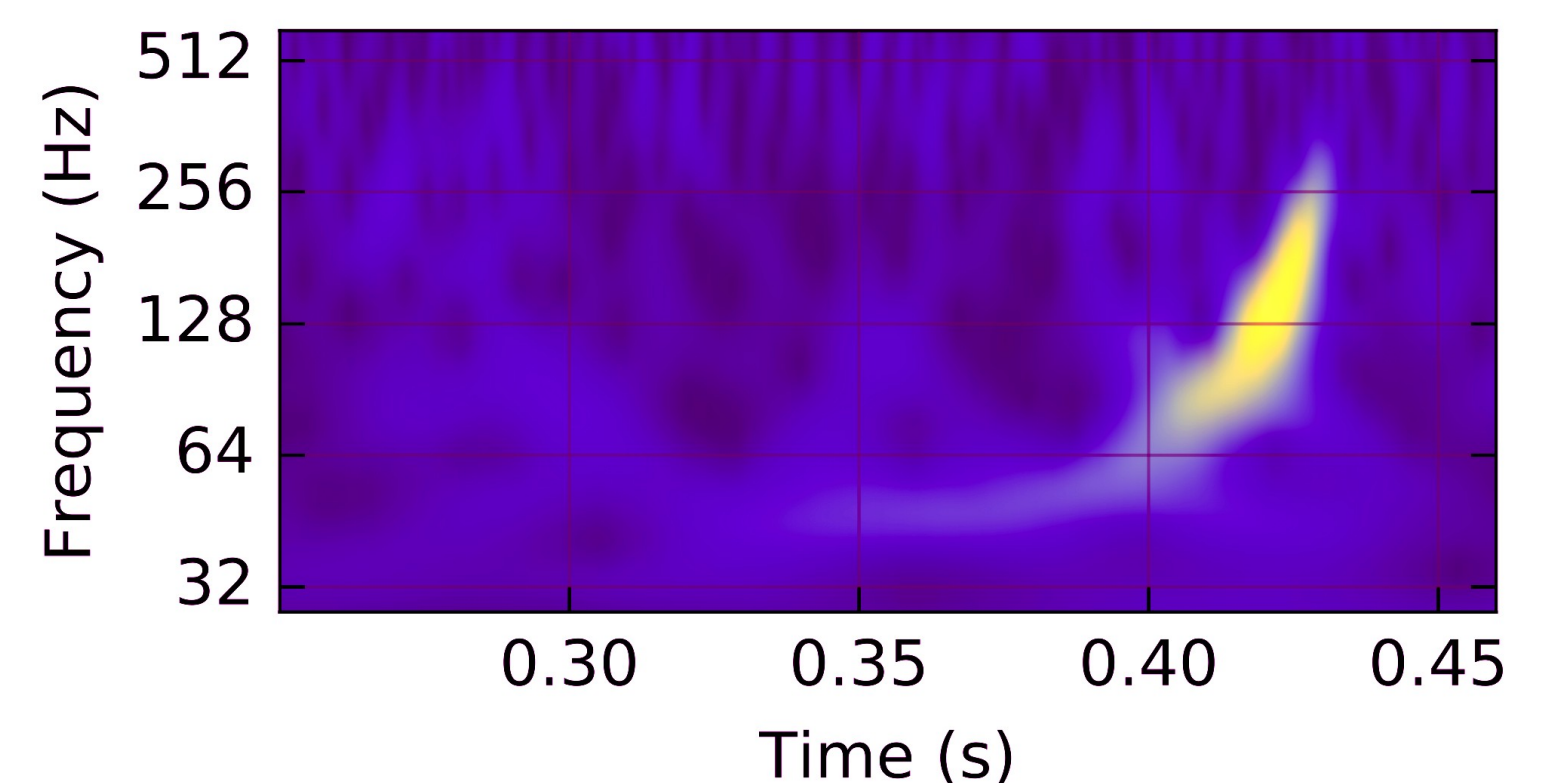
As the black holes' orbit shrinks with time, their orbital frequency increases

Gravitational wave frequency = 2 x orbital frequency

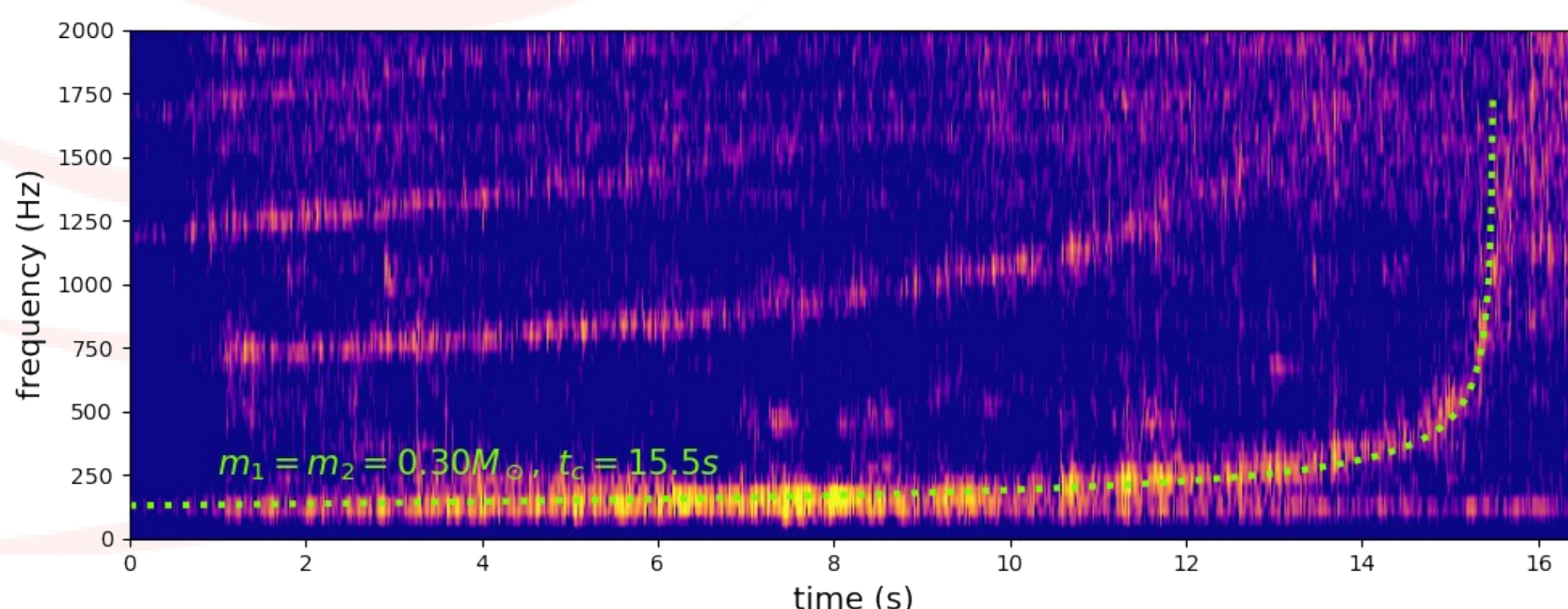


The frequency of **gravitational waves** increases with time as the black holes get closer!

This is clearly visible in LIGO's first detection of a black hole merger on 14 Sept. 2015



Scan to hear the sound of GW chirp bottle!



Scan to hear the sound of GWs detected by LIGO!

