Shaping the harmony of atoms using strong light

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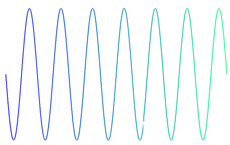
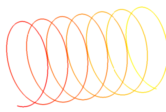
What kind of music can atoms play? Although they have no instruments, *atoms* – bricks of matter that build the world – can strongly interact with laser light and generate brief light flashes that can be as highly harmonic as music. Understanding how both lights are related through their interactions with atoms can help us follow events that happen too fast to be seen.



A light wave.

Firstly, light can be described as a wave, just like sound or vibrations on a string. An atom has a core to which *electrons* are bound; these are tiny orchestra players gathered around the core-conductor. Sometimes, electrons can however escape and travel away from the atom if an external light strong enough to disturb it – such as laser light – is directed on it. Imagine musicians being led by a conductor to play a music piece that only goes up and down in waves; some musicians may prefer to play something else instead (a concerto solo for instance) and will take a leave from the orchestra.

When these free electrons return to the atom, they will have gained too much energy from the laser light. Just as musicians must give up their concerto and play the conductor's wave music if they want to be back in the orchestra, electrons emit excess energy as light when they return to the atom. Every time the laser light is repeating its wave pattern (every time the conductor waves up and down its arm), this emission happens twice (one time up, one down). If this pattern is repeated very fast, the emitted light is emitted as brief *pulses*, whose duration is several attoseconds (1 attosecond = 1 billionth of a billionth of a second). These light pulses are far more harmonic than wave-shaped music who would contain a single tone.



Example of a circularly polarised light wave.

Light has also a property called *polarisation*, telling us which shape it takes when vibrating. For instance, a circular polarisation results in corkscrew-shaped vibrations since vibrations rotates along a circle. Of particular interest in my thesis was to investigate how laser light polarisation changes the light's shape and in turn the harmony of light pulses from atoms. By simulating the strong interactions between an atom and laser light, and by using a real-life attosecond pulse source, we saw for instance that harmony within pulses can sometimes be tuned to be stronger when light is polarised as an ellipsis.

In the future, this work will hopefully help us composing our own attosecond pulses, light flashes that allow us to take pictures of events almost as short as them – electrons moving around atoms, for instance – and to better understand how our world is built as whole by seeing more of it. So the next time you think about atoms, think of how the tiniest of musicians can play a much larger part in the universe – and thank them for the music.