

What are optical frequency combs?

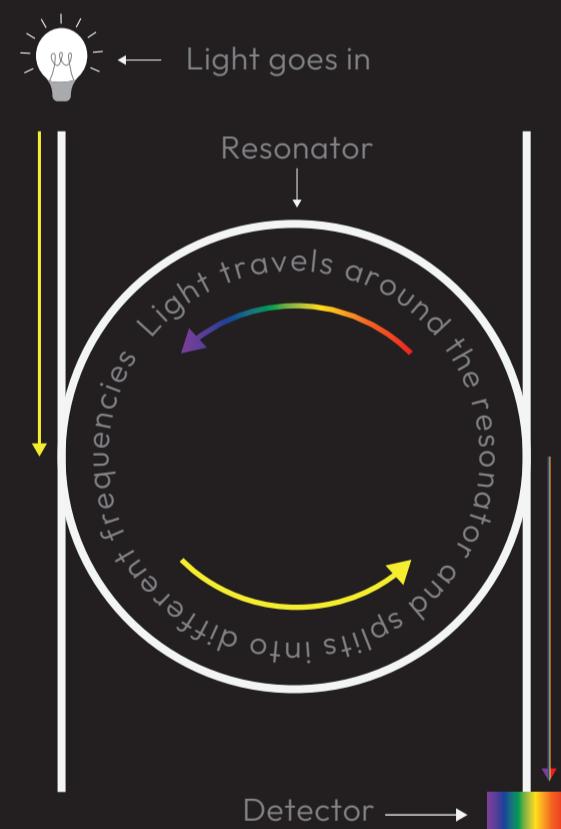
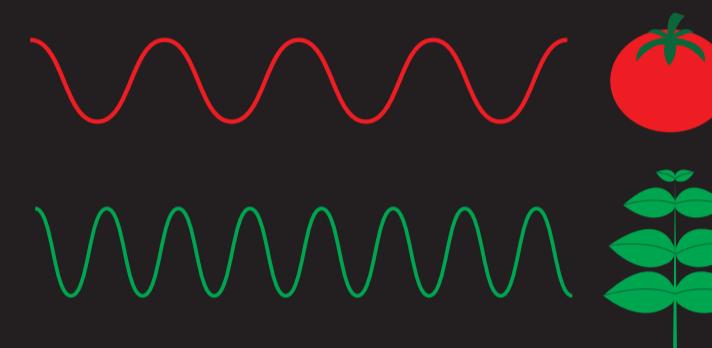
Optical frequency combs are the world's most precise rulers. They use light and can be used to measure position, frequency and time.



Why light?

Light is made up of a rainbow of colours ranging from very blue to very red. Light moves as waves and each colour oscillates at a different frequency. Frequency is based on how many waves cycle per second. Frequency tells us the energy of the wave and its corresponding colour. Colours with higher frequencies look bluer while colours with lower frequencies look redder.

When we see things, light receptor cells in our eyes detect different light frequencies to tell us what colour something is. It's how we know that leaves look green, and tomatoes look red.



How do combs work?

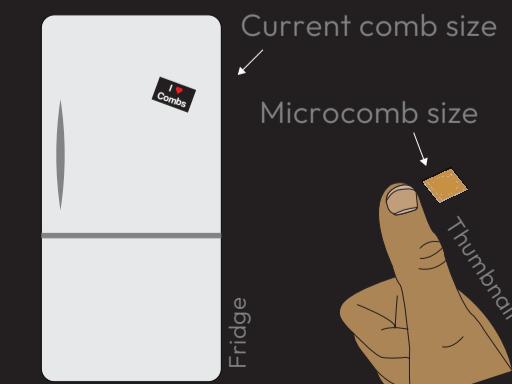
Combs generate light at equally spaced frequencies. In a comb, light is shone into a ring-shaped device called a resonator. Light travels around the resonator many, many times which splits it into different, equally spaced frequencies of different colours. Imagine one white-coloured car splitting into many different coloured cars as it goes around and round a racetrack. This split light is then read by a detector which tells scientists what the specific frequencies of light are and how big the spaces are between them.

What is a microcomb?

Microcombs are compact, inexpensive and easy to operate optical frequency combs. They're still in the experimental phase of development but could revolutionise science.

Why do we need microcombs?

Optical frequency combs are an amazing technology but are too big, expensive and complicated for everyday life. At COMBS, our researchers are working to shrink these combs to the size of a thumbnail to make them cheaper and easier for people to use.



COMBS

What are combs used for?

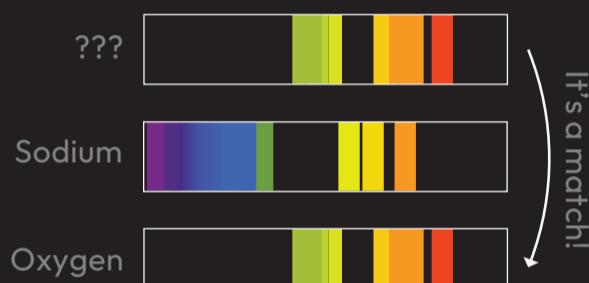
Combs have two main features:

1. They create a rainbow of light, with a precise selection of frequencies
2. These frequencies can be used as both as a ruler and clock

The ruler is used for measurement, detection and analysis while each of the different frequencies can be used for information sharing.

Detection

Scientists can use combs to find out what something is made of by comparing the frequencies of light that are absorbed/reflected by an unknown substance to known substances like atoms, molecules and ions.



Analysis

Combs produce equally spaced frequencies of light that can be matched to a ruler. If a sample emits an unknown frequency, it can be compared to the nearest known frequency on the ruler to help scientists work out what it is.

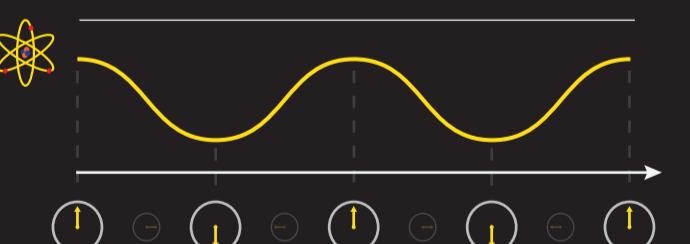
Information Sharing

Information on the internet is shared around the planet using light via fibre-optic cables in the ground and under the sea. Combs can help boost the number of frequencies (colours) of light sent down one cable to allow more people to connect to the internet faster.



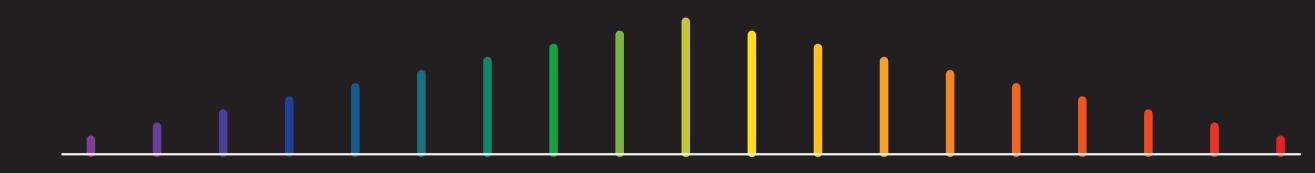
Measurement (or Time Keeping)

Combs can be used to make precise atomic clocks. Atoms regularly change and produce waves of light. Combs detect these waves and use the peak of the wave as the 'tick' of the clock to keep track of time.

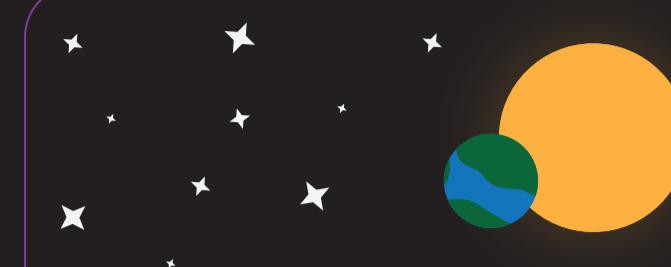


Why are they called combs?

Combs produce light at different evenly spaced frequencies that look like a series of spikes. Scientists thought these spikes looked like a comb you would use in your hair and named them accordingly!



How combs could be used in the real world



Space

Astronomers are using astrocobs – combs that measure the light produced by stars – to uncover the wonders of the universe. This includes searching for Earth-like planets.

Stars wobble a tiny amount if a planet is orbiting around them. Using astrocobs, scientists can detect these wobbles to help them identify distant planets like our own.

In the future, astronomers want to use small and stable microcombs to conduct long-term experiments. This includes a 50-year study to see how the universe expands in real-time by detecting changes in the sky.

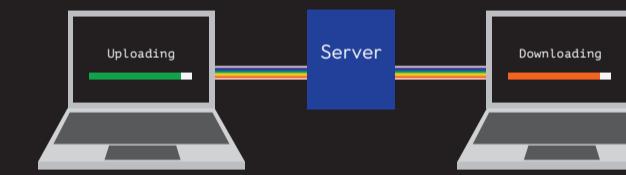


Health

When we buy avocados, we can tell how ripe they are by how squishy they feel. These textural differences are caused by mechanical changes in the cells of the fruit.

Our bodies are similar. Think of when you've fallen over and gotten a bruise, the skin (and tissue underneath) feels and looks different to how it normally does.

Scientists can use the light from combs to squish tissue and detect mechanical changes to help diagnose disease. In the future, they hope microcombs could be put into smart phones so doctors could conduct non-invasive tests from anywhere using the power of light.

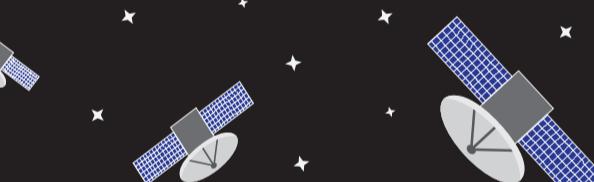


Connection

When we use the internet, information is sent from our devices to servers via fibre optic cables in the ground. These cables use laser light to send this data at very high speeds.

However, as the world uses more data for things like AI, GPS map directions, and streaming, our existing cables need a speed boost to keep up.

Scientists are using microcombs to boost the capacity of fibre optic cables by increasing the number of frequencies made by one device. One test found they could send over 40 terabytes of information – or thousands of movies – in one second, with a single microcomb. With more research, microcombs could help support our internet needs for years to come.



Travel

We use systems like GPS (Global Positioning System) every day to help us work out where we are and how to get to new places. GPS works by using super-accurate clocks on satellites floating 20,000km above the Earth.

GPS isn't just used for navigation, it also helps run things like the internet, electricity, banks and even traffic lights. If GPS signals are disrupted by bad space weather or people trying to block the signal, many parts of our lives would stop too.

That's where microcombs come in. Using tiny beams of light, scientists are developing super-precise measurement systems that will still work even if GPS fails, to keep the world running smoothly.