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The Nature of Light

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What is Light?

Is light a wave?
…and what IS a wave?

A wave in physics is when energy is transported through a medium without the transportation of matter

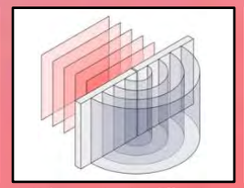
When we observe light, we see that it behaves like a wave. It interferes with itself; it diffracts and refracts.

Is light a particle?
…and what IS a particle?

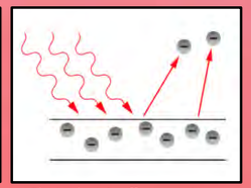
A particle in physics is an object which is localised in space and physically moves through space to move energy

Light also exhibits particle like properties. Einstein famously discovered this in 1905 with the photoelectric effect experiment.

Light interfering with itself, a wave property



Light experiencing diffraction, a wave property



Photoelectric effect proving particle like properties of light

Isn't it odd how something can behave like a wave AND a particle! The name given to these objects that have both particle and wave properties was 'Photons'. This this duality of properties has led to many more questions being asked in physics and many existing questions being explained with this concept.

Learn more about the duality of light here!
(https://youtu.be/wfK7GZoOYX0)

The Spectrum of Light

The wave properties of light lead to some interesting effects. One we experience every day and may not think twice about is colour!

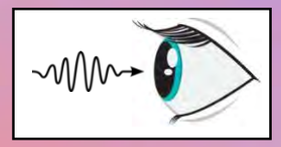
What is colour?

Equation for the Energy of a Photon

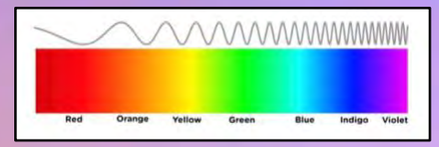
$$E = \frac{hc}{\lambda}$$

E = Energy
h = Plank's constant
c = Speed of light
λ = Wavelength

Light's colour depends only upon the wavelength of photons that make it up. This is because light moves at a constant velocity which means its energy is also only dependant on its wavelength.



The reason we can 'see' colour is because our eyes can differentiate between photons with different wavelengths.



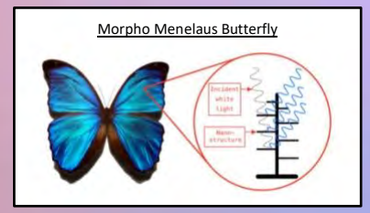
Light's colour can be represented as a continuous spectrum of wavelengths. This spectrum actually extends beyond the red and violet, these sections are aptly named infrared and ultraviolet.

So why do objects we see have colour?

White light is when a source of light (such as the Sun) is producing an equal number of photons from all visible wavelengths. How these photons interact with objects determine what colour we see them as.

An object we see as having colour means that it is reflecting the photons with wavelengths that make up that colour we see and absorbing the rest of incident wavelengths.

Morpho Menelaus Butterfly



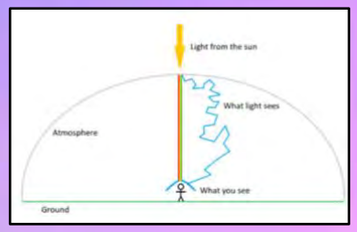
Nanostructures of an object's surfaces can cause interference which alters the incident light to always be reflected as a specific wavelength. In this case only blue light is reflected due to the spacing being equal to the wavelength of blue light.

Learn more about the spectrum of light here!
(https://youtu.be/jpNiVwVshS0)

Phenomena of Light

We encounter phenomena of light every day. For us humans it is our primary way of sensing our environment. So, it is natural to wonder why/how these effects are occurring.

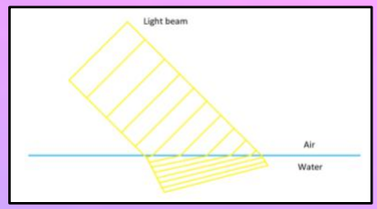
What causes the sky to be blue?

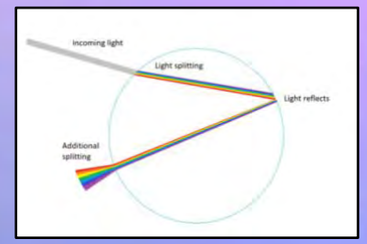


The answer is something called Rayleigh scattering. Light from the sun is coming in from the top. Most of it goes straight but the blue light is bouncing about in the atmosphere and coming in at different angles.

What about rainbows?

Rainbows form due to two processes; one is reflection like in a mirror, the other is refraction which is shown here.
The light crossing the boundary causes it to slow down, this causes it to curve.





The different colours of light curve at different angles which causes them to split like is seen here. The light then reflects off the other side of the droplet. Finally, the light splits even more as it refracts at the other side of the droplet.

Learn more about these phenomena of light here!
(https://youtu.be/zehKnigHZV0)