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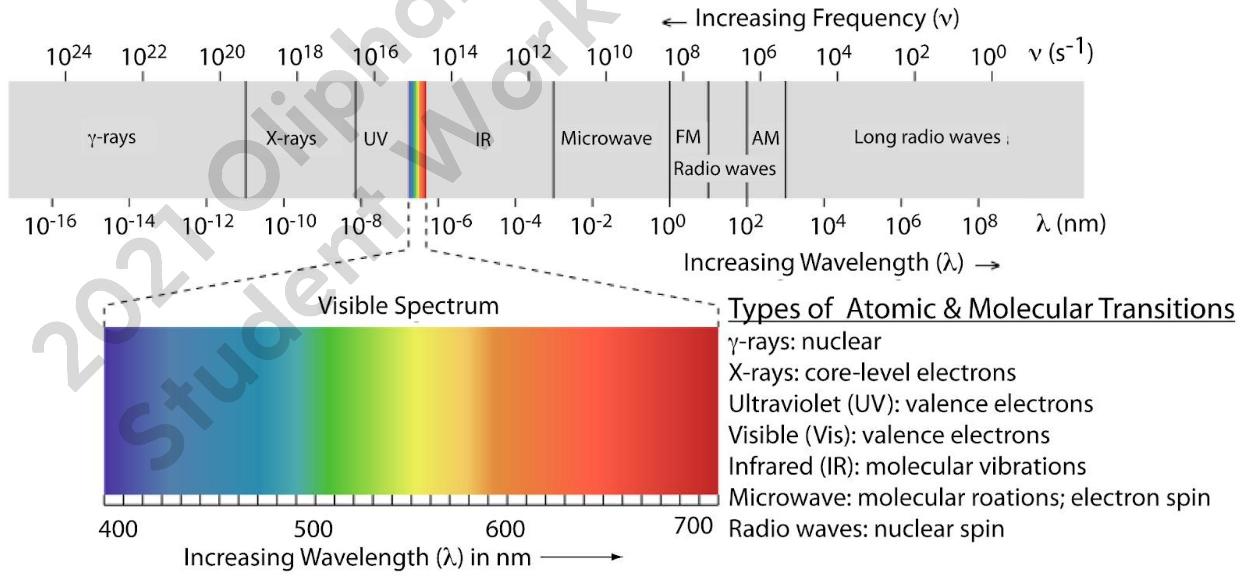
Playing With Light - Yifan

In this essay, I will talk about light and how it can be manipulated. Physics itself is a very broad topic, and it engages hundreds of thousands of students to study this particular field of science. However, of these hundreds of thousands, there are a select few who have made a massive indent on physics and how we understand how the world works.

That area of physics is called optics, which we defined in 1925. The birth of optics in this time made it clear to us that light is made up of tiny units called photons. This is a very important research area in modern science. Photons can be described as tiny packets of energy. When an object's atoms heat up, photons are produced from the movement of the atoms. In relation to this, the hotter an object gets, the more photons are produced.

Photons are the smallest quantum of electromagnetic radiation and are defined as the basic unit of all light. Photons are always in motion and in a vacuum, they have a constant speed of 2.998 x 10^8 m/s to all observers. This is otherwise known as the speed of light, and in equation form, it is represented as *c*. An example of this is Einstein's famous equation, $e=mc^2$. In which *e* represents energy, *m* represents mass, and c^2 represents the speed of light squared. To go faster, more energy is needed and at a certain point, an object cannot go faster because it is too close to the speed of light. Even if energy is added to the object to make it go faster, it does not go any faster because that is its limit. However, the energy has to go somewhere, so where does it go? Well, the energy is actually converted into mass. The object itself will gain more mass if energy is added to it once it reaches its limit. No object can travel faster than 3.0 x 10^8 m/s, which is the fastest an object can travel.

In physics, light is alternately known as electromagnetic radiation that the human eye can see. Light, or electromagnetic radiation, actually has an extremely large range of wavelengths, from gamma rays to radio waves. Within this large spectrum, the human eye can only detect a very small part of it, approximately from about 600 nanometres down to about 400 nanometres. The picture below depicts this description.



The frequency of light is the amount of cycles of light that pass a select point in a second. The frequency of visible light is colour which ranges from 430 trillion hertz to 750 trillion hertz. The unit for frequency is sometimes called hertz (Hz) and is also depicted using units per second. Which is written as s^{-1}. It is usually represented by the Greek letter ν (Nu), which is used to represent the 'n' sound in Greek.

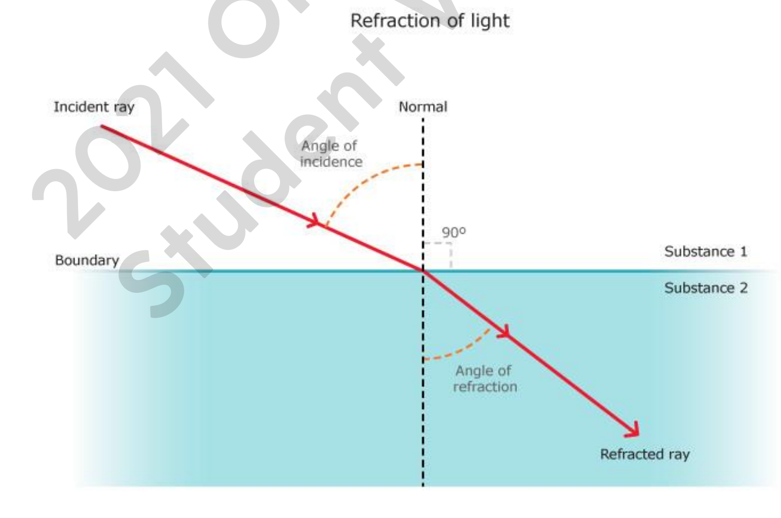
The definition of a wavelength of light is the distance between two corresponding points in two adjacent light cycles. Since light travels in waves and travels at around 3 x 10^8 metres/second through a vacuum such as space. A wavelength is one cycle of that wave and is measured by taking the distance between any two consecutive points on the wave. The unit for wavelength is metres and is typically represented by the Greek letter λ (Lambda), which is used to represent the 'l' sound in Greek.

Gamma rays are a form of electromagnetic radiation that occurs from radioactive decay of atomic nuclei. Simply put, they are photons that are emitted from radionuclide, which is when there is an unstable nuclide that emits ionising radiation, which then causes radioactive decay. Gamma photons are the most energetic photons in the electromagnetic spectrum because they are at the top of it, which means all extremely high-energy photons are gamma rays.

Radio waves are waves from a portion of the electromagnetic spectrum which typically have a frequency range between 10^4 and 10^{11} or 10^{12} Hz. Radio wave communication signals travel through the air in a straight line and reflect off of clouds, layers of the ionosphere, or are repelled by satellites in space.

Light itself is the fastest thing to exist and nothing can be faster than it. According to Einstein's Theory Of Relativity, the speed of light is constant and does not change no matter how fast another object may be travelling, thus meaning that the speed of light is absolute. His theory also states that the closer an object is travelling to the speed of light, the slower time will become for the object.

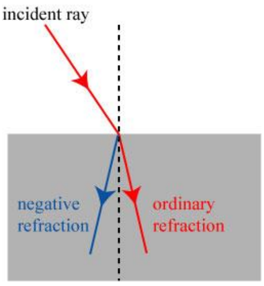
Refraction is the phenomenon of light being reflected in passing obliquely through the interface between one medium and another or through a medium of varying density. More simply put, it is when light bends as it passes through a transparent substance and into another. Some examples of refraction are in microscopes, lenses, and even our eyes. Without refraction, we wouldn't be able to focus light into our retina. When light enters a substance a denser substance than water, (high refractive index), it bends more towards the 'normal' line. The amount of refraction, or bending depends on two things. These two things are if the substance makes the light's speed change, it will refract more. The other reason is the angle of which the light is entering the substance. If the angle is greater, then the amount of refraction will also be greater, thus being more noticeable. Contrastingly, if the light is entering the substance straight on, the light will slow down but not change direction. The picture below depicts light refraction when the medium is water.



Due to refraction and the way that light travels when it passes through a medium, people are able to interfere and 'play' with light by changing the medium or the angle of incidence as to which the light ray may be entering at. This changes the refracted ray. This is how a microscope lens works. It manipulates light and changes how it enters the eye by using the convex lens, which is where both sides of the lens are curved outwards. To make an object magnified, light reflects off of the object and passes through the lens and then bends towards the eye. The function of the convex lens is to bend the parallel rays so that they connect and then create an image for our eyes. That is how a microscope magnifies an object and allows our retina to see the object at a larger size.

Metamaterials are things that have the ability to manipulate electromagnetic waves, such as visible light, in order to make them behave in certain ways that are not found in nature, such as a negative index of refraction or electromagnetic coating. This is a massive breakthrough and since this discovery, which was made in 1897, scientists have been using this ability to manipulate light in order to make new breakthroughs, such as super-high resolution imaging.

Negative-Index Metamaterials, or negative refraction, causes light to bend or refract differently compared to common positive-index materials. In other words, using negative-index metamaterials will allow for a 'perfect lens' which would allow a very high quality image. This would allow for very accurate images to analyse for scientists and could potentially lead to discoveries that previously might've not been possible. This is a very important discovery because using this would also allow scientists to confirm previous theories as well as allow for further scientific development and discovery in the future. A negative refraction would look like the blue line in the picture below.



In conclusion, light can be manipulated in various different ways in order to contribute to the benefit of modern society. Some examples of which include, spectacles, photography, and microscopes. The human eye can only detect a very small part of the electromagnetic spectrum, which is called the visible spectrum. The electromagnetic spectrum contains many colours which occur depending on the wavelength but humans are only able to detect colours on the light spectrum ranging from 400 nanometres to 700 nanometres. Refraction also plays a very large part in the manipulation of light in modern society because of its uses. Manipulation of light plays a very large part in the functioning of modern day society and the world would not be the same if the Dutch physicist, Christian Huygens did not establish the wave theory of light and did not announce the Huygens' principle.

Sources

Electromagnetic Spectrum 2020, Photograph, Chemistry LibreTexts, viewed 29 June 2021, <https://www.google.com/url?sa=i&url=https%3A%2F%2Fchem.libretexts.org%2FCourses%2FPacific_Union_College%2FQuantum_Chemistry%2F13%253A_Molecular_Spectroscopy%2F13.01%253A_The_Electromagnetic_Spectrum&psig=AOvVaw0VOjMXgAK8OkbT5GylKnlD&ust=1625059953665000&source=images&cd=vfe&ved=0CAoQjRxqFwoTCNiEqsP6vPECFQAAAAAdAAAAABAD>. *Gamma radiation n.d.* Available at: https://www.arpansa.gov.au/understanding-radiation/what-is-radiation/ionising-radiation/gamma-radiation (Accessed: 29 June 221).

Light (2021). Available at: https://saylordotorg.github.io/text_introductory-chemistry/s12-01-light.html (Accessed: 29 June 2021).

Negative Refraction 2009, Photograph, Skulls in the Stars, viewed 30 June 2021, <https://www.google.com/url?sa=i&url=https%3A%2F%2Fskullsinthestars.com%2F2009%2F05%2F19%2Fwhat-does-negative-refraction-look-like%2F&psig=AOvVaw3zpcoePbhE-tqtL6e2p6aC&ust=1625146938685000&source=images&cd=vfe&ved=0CAoQjRxqFwoTCJCVk6K-v_ECFQAAAAAdAAAAABAD>.

radio wave | Examples, Uses, Facts, & Range (2021). Available at: https://www.britannica.com/science/radio-wave (Accessed: 29 June 2021).

Refraction Of Light In Water 2012, Photograph, Science Learning Hub, viewed 24 June 2021, <https://www.sciencelearn.org.nz/images/49-refraction-of-light-in-water>.

Scientists design new material to harness power of light: Technology will improve optical computing, telecommunications (2021). Available at: https://www.sciencedaily.com/releases/2018/12/181217151526.htm (Accessed: 25 May 2021).*Refraction Of Light In Water* 2012, Photograph, Science Learning Hub, viewed 24 June 2021, <https://www.sciencelearn.org.nz/images/49-refraction-of-light-in-water>.