ELECTROMAGNETIC WAVES

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At the time when Maxwell first proposed the existence of electromagnetic waves, the only ones we were familiar with were visible light waves. Back then, we had just started to understand the existence of ultraviolet and infrared waves. As the 19th century came to a close, X-rays and gamma rays were also discovered. Fast forward to today, we've come to learn that electromagnetic waves span a wide range, including visible light waves, X-rays, gamma rays, radio waves, microwaves, ultraviolet, and infrared waves.

These waves are classified based on their frequency, and this classification is known as the electromagnetic spectrum. It's important to note that there isn't a strict boundary between one type of wave and the next; the classification is more about how these waves are generated or detected.

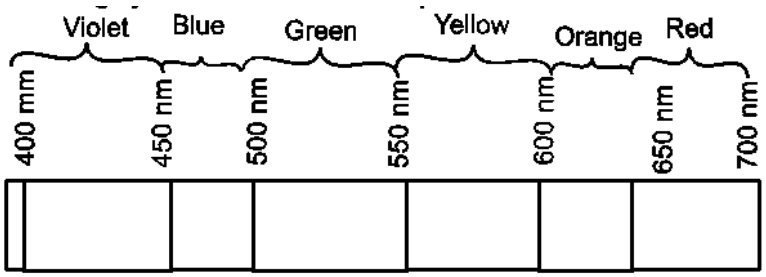


Figure - spectrum of visible light

We will now provide a brief description of various types of electromagnetic waves in the order of decreasing wavelengths.

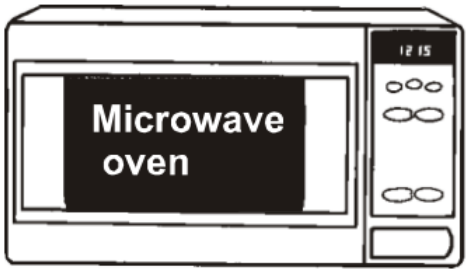
Radio waves

Radio waves are generated when charges in conducting wires undergo accelerated motion. They play a crucial role in radio and television communication systems. Radio waves span a frequency range from approximately 500 kHz to around 1000 MHz. The AM (amplitude modulated) band encompasses frequencies from 530 kHz to 1710 kHz. Frequencies up to 54 MHz are designated for shortwave bands. Television waves occupy the range from 54 MHz to 890 MHz. Meanwhile, the FM (frequency modulated) radio band covers frequencies between 88 MHz and 108 MHz. Ultrahigh frequency (UHF) radio waves are used for cellular phones to transmit voice communications.

Microwaves

Microwaves, which are essentially short-wavelength radio waves, have frequencies measured in the gigahertz (GHz) range. They are generated using specialized vacuum tubes known as klystrons, magnetrons, and Gunn diodes. Thanks to their shorter wavelengths, microwaves are well-suited for radar systems employed in aircraft navigation.

An interesting domestic application of microwaves can be seen in microwave ovens. In these appliances, the microwave frequency is carefully chosen to match the resonant frequency of water molecules, allowing the waves to efficiently transfer energy to the kinetic energy of these molecules. As a result, the temperature of food containing water is raised.



Infrared waves

Infrared waves, often called heat waves, are generated by hot objects and molecules. These waves fall at the lower-frequency, longer-wavelength end of the visible spectrum. Infrared waves are commonly associated with heat because most materials, containing water molecules, efficiently absorb them. This absorption leads to an increase in thermal motion, causing the material to warm up and heat its surroundings.

In various applications, such as physical therapy, infrared lamps are used. Additionally, infrared radiation plays a vital role in maintaining the Earth's average temperature through the greenhouse effect. Incoming visible light from the Sun, which easily penetrates the atmosphere, is absorbed by the Earth's surface and then re-emitted as longer-wavelength infrared radiation. Greenhouse gases, like carbon dioxide and water vapor, trap this infrared radiation, helping to keep the Earth warm.

Infrared detectors are employed in Earth satellites for various purposes, including military applications and monitoring crop growth. Moreover, electronic devices, such as semiconductor light-emitting diodes, emit infrared radiation, which is commonly used in remote controls for household electronics like TV sets, video recorders, and hi-fi systems.

Visible rays

Visible light is the electromagnetic wave that we encounter most frequently. It falls within the part of the spectrum that can be detected by the human eye. This range spans from approximately 4×10^{14} Hz to about 7×10^{14} Hz, corresponding to a wavelength range of about 700 to 400 nanometers (nm). When objects emit or reflect visible light, it provides us with valuable information about the world around us. Our eyes are specifically attuned to this particular range of wavelengths.

It's important to note that different animals possess varying sensitivities to different wavelength ranges. For instance, snakes have the ability to detect infrared waves, which are invisible to us, and many insects have a 'visible' range that extends well into the ultraviolet part of the spectrum. This diversity in sensitivity to light allows different species to perceive the world in distinct ways.

Ultraviolet rays

Ultraviolet (UV) radiation covers a range of wavelengths from approximately 4×10^{-7} m (400 nm) down to 6×10^{-10} m (0.6 nm). Ultraviolet light is generated by specialized lamps and very hot objects. The sun serves as a significant natural source of ultraviolet light, but thankfully, most of it is absorbed by the ozone layer in the Earth's atmosphere, which is located at an altitude of about 40-50 kilometers.

Exposure to high levels of UV radiation can have harmful effects on human health. For example, when we are exposed to UV radiation, our bodies produce more melanin, leading to tanning of the skin. It's important to note that regular glass can effectively block UV radiation, so you won't get a tan or sunburn through glass windows. In situations where individuals are exposed to substantial amounts of UV radiation, such as welding, special glass goggles or face masks with UV-blocking glass windows are worn to protect their eyes.

Due to its shorter wavelength, UV radiation can be concentrated into highly focused beams for precision applications like LASIK (Laser Assisted in Situ Keratomileusis) eye surgery. UV lamps are also utilized for disinfecting water by killing germs in water purifiers.

The ozone layer in the Earth's atmosphere plays a vital protective role, shielding us from excessive UV radiation. The depletion of this ozone layer, primarily caused by the release of chlorofluorocarbons (CFCs), is a significant international concern.

X-rays

The X-ray region of the electromagnetic spectrum is situated beyond the UV region and is known for its medical applications. It encompasses wavelengths ranging from approximately 10^{-8} m (10 nm) down to 10^{-13} m (10^{-4} nm). One commonly employed method to produce X-rays is by subjecting a metal target to high-energy electrons. X-rays are extensively used for diagnostic purposes in the field of medicine and are also employed in the treatment of specific types of cancer.

It's important to note that X-rays possess the capacity to harm or obliterate living tissues and organisms, making it crucial to exercise caution and prevent unnecessary or excessive exposure to them.

Gamma rays

Gamma rays are a type of electromagnetic waves that have very high frequencies and extremely short wavelengths. They are at the upper end of the electromagnetic spectrum, with wavelengths ranging from about 10^{-10} m to less than 10^{-14} m. Gamma rays are produced in processes like nuclear reactions and are also emitted by radioactive materials.

In medicine, gamma rays are used to treat cancer cells because of their high energy. These waves are focused on the cancerous tissue to damage and destroy it. It's a precise way to target and eliminate harmful cells.

In summary, electromagnetic waves cover a wide range of frequencies and wavelengths, and gamma rays are at the very high-energy end of this spectrum. The transition between different types of electromagnetic waves is not always distinct, and there can be some overlap between them.