Black body radiation

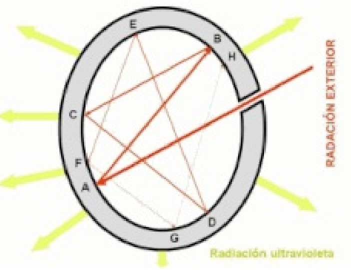
Every body, especially heated to a high temperature, emits thermal electromagnetic radiation due to the thermal excitation of atoms . When radiation hits a body, the body can **absorb** or **reflect** the radiation.

Kirchhoff's law

According to *Kirchhoff's law* of radiation, the **continuous spectrum** (= contains electromagnetic waves of all wavelengths) emitted by real bodies depends both on their **temperature** and **absorption capacity** . *And that is why a physical model, the so-called **black body*** , is introduced to describe radiation . This body **perfectly absorbs** all incoming electromagnetic radiation, so it does not reflect or transmit any radiation. The radiation of a black body then depends **only on its thermodynamic temperature** . The more radiation a black body absorbs, the more its temperature will increase – that is, the black body will emit thermal radiation. The amount of absorbed radiation depends on **color** (black bodies absorb the best) and **surface** (radiation is reflected from shiny bodies , whereas matte bodies absorb more radiation).

Blackbody radiation can be thought of as a **hollow cube with a very small opening** into the cavity. The inner surface of the cavity is a matte black surface. Radiation falling into the cavity through a small opening is absorbed after repeated reflections, i.e. that the **small opening appears to the outside as an absolutely black body** (absorbs all incident radiation).

The radiation of the Sun can also be compared to the radiation of a black body with a temperature of around 5800 K. **The Sun** can be considered an absolutely black body because its volume, in which the radiation is generated, is large compared to the surface through which the radiation reaches the outside. The surface of the Sun therefore represents a kind of "hole into the cavity" (see figure).



An all-black body model

Laws of black body radiation

Wien's displacement law

The wavelength λ_{max} , which corresponds to **radiation with the greatest intensity** , is inversely proportional to the thermodynamic temperature of the black body. This dependence was discovered at the end of the 19th century by the Austrian physicist W. Wien (1864–1928). The constant *b* takes on the value $b = 2.898 \times 10^{-3}$ mK. So, at lower temperatures, the maximum radiation intensity falls on "longer" wavelengths, as the temperature increases, the wavelength λ_{max} shifts to the short-wave end of the spectrum.

$$\lambda_{max} = \frac{b}{T}$$

Stefan-Boltzmann law

The Austrian physicists Josef Stefan and Ludwig Boltzmann also tried to describe black body radiation using classical physics . They found that the black body radiation intensity M_e is **directly proportional to the fourth power of the thermodynamic temperature T** of the black body, i.e. $M_e = \sigma T^4$, where the Stefan-Boltzmann constant σ takes on the value $\sigma = 5.67 \times 10^{-8}$ $\mathrm{W m^{-2} K^{-4}}$.

Planck's law

All the shortcomings of the laws describing the radiation of a black body were removed only by the German physicist Max Planck in 1900. He expressed the simplifying hypothesis that a black body cannot emit or absorb energy in an arbitrary amount, but **discontinuously after quanta** . He then assigned an energy to each quantum of radiation, which is directly proportional to the frequency of the radiation. *E* is the energy of a quantum of radiation, *f* its frequency, *l* the wavelength, *c* the speed of light in a vacuum, and *h* **Planck's constant** ($\mathbf{h = 6.626 \times 10^{-34}}$ **Js**).

Based on this simplification, he compiled an equation in 1900 that describes the radiation of an absolutely black body in all areas of the electromagnetic wave spectrum, for which he was awarded the Nobel Prize in 1918. This equation became fundamental to quantum physics . H_λ is the spectral density of radiation intensity defined as the amount of energy per unit interval of wavelength, *k* is Boltzmann's constant.

$$H_\lambda = \frac{2\pi h c^2}{\lambda^5 \left(\mathrm{e}^{\frac{hc}{k\lambda T}} - 1 \right)}$$

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

Links

Related Articles

- Radiant energy

External Links

- Absolute black body radiation (Encyclopedia of Physics J. Reichl) (http://fyzika.jreichl.com/main.article/view/538-zareni-absolutne-cerneho-telesa)