Black-bodyradiation

The term *black body* was introduced by Gustav Kirchhoff in 1860.Black-body radiation is also called ***thermal radiation, cavity radiation, complete radiation* or *temperature radiation.***

Black-body radiation is the thermal electromagnetic radiation within or surrounding a body in thermodynamic equilibrium with its environment, emitted by a black body(an idealized opaque, non-reflective body). It has a specific spectrum of wavelengths, inversely related to intensity that depends only on the body's temperature, which is assumed for the sake of calculations and theory to be uniform and constant.

The thermal radiation spontaneously emitted by many ordinary objects can be approximated as black-body radiation. A perfectly insulated enclosure that is in thermal equilibrium internally contains black-body radiation and will emit it through a hole made in its wall, provided the hole is small enough to have negligible effect upon the equilibrium.

A black body at room temperature appears black, as most of the energy it radiates is in the infrared *spectrum* and cannot be observed by the human eye. Since the human eye cannot identify light waves below the visible frequency, a black body, viewed in the dark at the lowest just lightly visible temperature, subjectively appears grey, even though its objective physical spectrum peak is in the infrared range. When it becomes a little hotter, it appears dull red. As its temperature increases further it becomes yellow, white, and ultimately blue-white.

Although planets and stars are neither in thermal equilibrium with their surroundings nor perfect black bodies, black-body radiation is used as a first approximation for the energy they emit. holes are near-perfect black bodies, in the sense that they absorb all the radiation that falls on them. It has been proposed that they emit black-body radiation (called Hawking radiation), with a temperature that depends on the mass of the black hole.

Black-body radiation has a characteristic, continuous frequency spectrum that depends only on thebody's temperature, called thePlanck. Thespectrum is peaked at a characteristic frequency that shifts to higher frequencies with increasing temperature, and at room temperaturemost of the emission is intheinfrared region of the electromagnetic spectrum. As the temperature increases past about 500 degrees Celsius, black bodies start to emit significant amounts of visible light. Viewed in the dark by the human eye, the first faint glow appears as a "ghostly" grey(thevisible light is actuallyred, but low intensity light activates only theeye's grey-level sensors). With rising temperature, the glow becomes visible even when there is some background surrounding light: first as a dull red, then yellow, and eventuallya"dazzlingbluish-white"asthetemperaturerises.Whenthebody appears white, it is emitting a significant fraction of its energy as ultraviolet radiation. The Sun, with an effective temperature of approximately 5800 K, is an approximate black body with an emission spectrum peaked in the central, yellow-green part of the visible spectrum, but with significant power in the ultraviolet as well. Black-body radiation provides understanding into the thermodynamic equilibrium state of cavity radiation.

An object that absorbs all radiation falling on it, at all wavelengths, is called a ***black body***. When a black body is at a uniform temperature, its emission has a characteristic frequency distribution that depends on the temperature. Its emission is called black-body radiation.

A black body radiates energy at all frequencies, but its intensity rapidly tends to zero at high frequencies (short wavelengths). For example, a black body at room temperature (300 K) with one square meter of surface area will emit a photon inthe visible range (390–750 nm) at an average rate of one photon every 41 seconds, meaning that for most practical purposes, such a black body does not emit in the visible range.

Theblack-bodylawmaybeusedtoestimatethetemperatureofaplanetorbiting the Sun.

Thetemperatureofaplanetdependson several factors:

- ***Incidentradiationfromitsstar***

- ***Emittedradiationoftheplanet,e.g.,Earth'sinfraredglow***
- ***Thealbedo effectcausingafractionoflighttobereflectedbytheplanet***
- ***Thegreenhouseeffectforplanetswithanatmosphere***
- ***Energygeneratedinternallybyaplanetitselfdueto radioactivedecay,tidalheating, and adiabatic contraction due by cooling.***

Planck's law of black-body radiation

$$B_\nu(\nu,T) = \frac{2h\nu^3}{c^2}\frac{1}{e^{h\nu/kT}-1}$$

$B_\nu(T)$ is the spectral radiance (the power per unit solid angle and per unit of area normal to the propagation) density of frequency ν radiation per unit frequency at thermal equilibrium at temperature T.

h is the Planck constant;

c is the speed of light in a vacuum;

k is the Boltzmann constant;

ν is the frequency of the electromagnetic radiation;

T is *the absolute temperature of the body*.

Wien's displacement law

Wien's displacement law shows how the spectrum of black-body radiation at any temperature is related to the spectrum at any other temperature. If we know the shape of the spectrum at one temperature, we can calculate the shape at any other temperature. Spectral intensity can be expressed as a function of wavelength or of frequency.

A consequence of Wien's displacement law is that the wavelength at which the intensity *per unit wavelength* of the radiation produced bya black body has a local maximum or peak, λ_{peak}, is a function only of the temperature:

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

where, the constant b, known as Wien's displacement constant, is equal to$2.897771955 \times 10^{-3}$ m K. At a typical room temperature of 293 K (20 °C), the maximum intensity is at 9.9 μm.