Friday, October 5, 2018

The spatial luminous power of Space.

Black-body radiation.

The Black-body radiation, also called Complete radiation or Thermal radiation, is the type of electromagnetic radiation inside or surrounding a body in thermodynamic equilibrium with its environment, or emitted by a black body (an opaque and non-reflective body) maintained at a constant and uniform temperature.

Radiation has a specific spectrum and intensity that depends only on body temperature.

Thermal radiation spontaneously emitted by ordinary objects can be approximated by blackbody radiation.

A perfectly insulated chamber, in internal thermal equilibrium, contains a black body radiation, which can be emitted through a hole made in its wall, provided that the hole is small enough that its effect is negligible on the equilibrium.

A black body at room temperature will appear black because most of the energy emitted is located in the infrared range, which can not be perceived by the human eye.

As the human eye is unable to perceive color at low light intensities, a dark body observed in the dark at the lowest temperature will be faintly visible, and will appear subjectively gray, even if its physical spectrum reaches its maximum level in infrared.

When it gets a little warmer, it takes on a dull red color.

As its temperature increases, its wavelength decreases to a dazzling blue-white color.

Despite the fact that planets and stars are neither in thermal equilibrium with their environment nor perfect black bodies, black body radiation is used as a first approximation of the energy they emit.

Black holes are almost perfect black bodies, in the sense that they absorb any radiation that strikes them. However, they would emit a black body radiation (called Hawking radiation) according to a temperature proportional to their mass.

The black body radiation has a continuous and characteristic frequency spectrum that depends only on its temperature, called the black body spectrum and described by Planck's law.

The spectrum reaches its maximum at a characteristic frequency that shifts to higher frequencies as the temperature increases, and most of the ambient temperature emission is in the infrared region of the electromagnetic spectrum.

When temperatures exceed 500 degrees Celsius, black bodies begin to emit a significant amount of visible light.

When viewed in the dark, they are of a low-gloss gray, but only because the human eye is sensitive only to black and white at very low intensities.

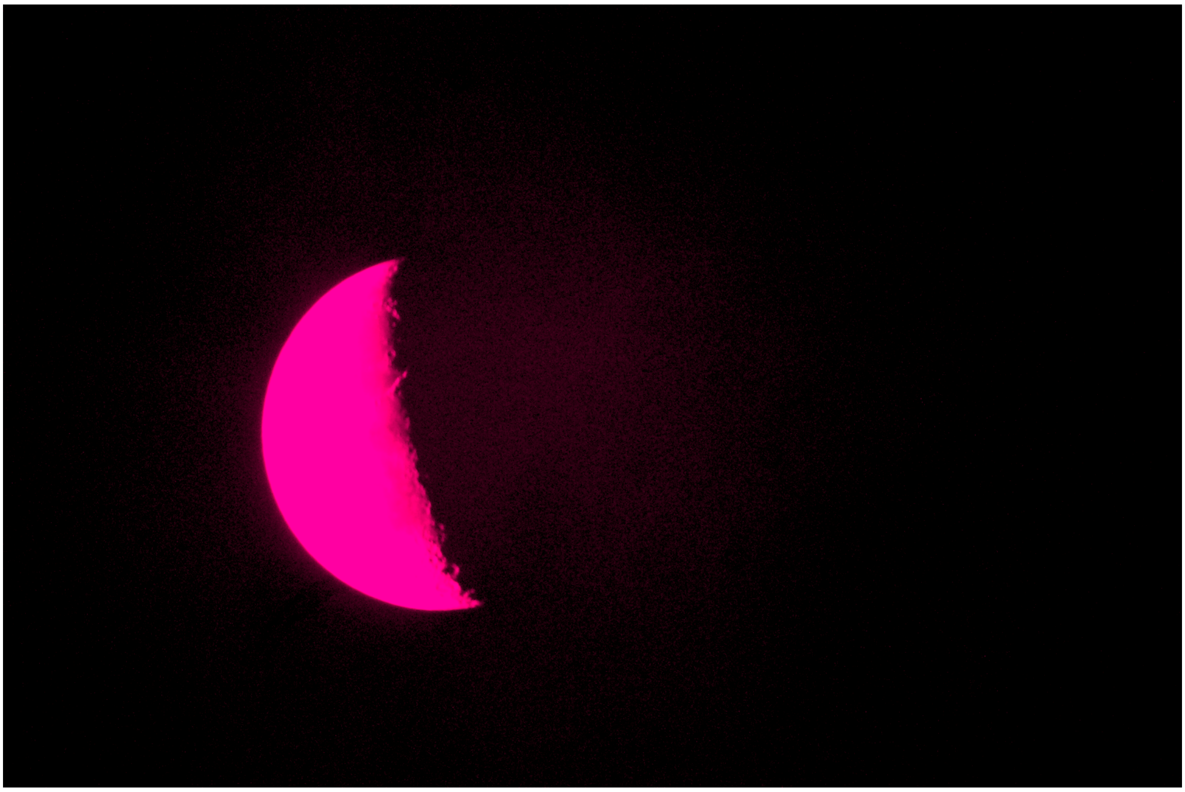
In reality, the frequency of light in the visible field is red, however, the intensity is too low to be discerned as red.

As the temperature increases, the body becomes visible even when there is ambient light.

It takes colors first of dull red, then of yellow and finally, he emits a dazzling white-bluish light.

Although it remains of this color to the eye, the increase of temperature brings its peak of emissivity in the ultraviolet radiation.

The Sun, with an effective temperature of about 5,800 K, can be considered as a black body having an emission spectrum whose emissivity peak is located in the central and yellow-green part of the visible spectrum, but with a significant power in the ultraviolet also.



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The light that sends back by the Moon.

We can distinguish exactly the same absorption lines as in the spectrum of the Sun.

This is a first indication of the lack of atmosphere of the Moon, otherwise it would change the spectrum.

Light also helps to get an idea of the lunar soil.

A piece of coal does not return the light like a white stone.

A smooth-surface returns light in a particular direction, such as the surface of a lake = specular reflection.

A porous surface, like pumice, returns light in all directions, but absorbs much of it in countless small holes on its surface.

A porous surface polarizes the light it reflects.

By calculation, we can determine the brightness of each phase, since we know the angle under which the Sun illuminates the lunar soil, and the angle at which it returns the light, according to the supposed properties of the soil.

When we plot the theoretical curves corresponding to the different types of soil, and the measured curve, on the same graph, we can select the theoretical curve that comes closest to the reality.

The type of soil models is the one that comes closest to reality.

This showed that: the Moon is not a very good reflector, and especially that its soil must be porous.

If we assume that the surface has many small holes, the reflectance will be good vertically, and worse and worse if we deviate from it.

Hence the idea that the lunar soil could be covered with dust, in which a spaceship could sink.

From the first probes shipped there, we knew that the ground was strong enough to support a craft spatial.

The porosity was confirmed by the discovery of the polarization of the lunar light.

The ground is very dark: the Moon absorbs 92.7% of the light it receives from the Sun.

The albedo is only 0.073 which is really very weak.

Being very dark, the Moon absorbs the rays of the Sun and heats up.

The surface reaches 130 ° C in the Sun.

On the other hand, as soon as the Sun goes down, the cooling is brutal, because there is no atmosphere like here to retain the heat a little like a blanket .. on Earth when the weather is covered, there is no has no frosts.

They can occur only on a clear day, when the floor radiates towards space, the heat received during the day.

The lunar rocks are therefore subjected to a severe test: at sunrise, they pass very quickly from -150 ° C to +
130 ° C and, at bedtime they cool down just as quickly.

This produces a degradation of the rocks, which slowly reduces them to powder.

The astronauts who landed on the moon found this dust on the ground: called regolith.

It explains the optical-properties of the Moon.

In astronomy, several bodies emit spectra similar to those emitted by black bodies.

First, objects such as stars are frequently seen as black bodies, although this is a bad approximation.

Then, the cosmic microwave background illustrates an almost perfect black body spectrum.

Finally, the Hawking radiation, hypothetical radiation emitted by black holes, has a temperature that depends on the mass, the charge, and the spin of the hole.

Relationship of the temperature between a planet and its star:

The black body radiation law can be used to estimate the temperature of a planet orbiting the Sun.

- **The temperature of the planet depends on several factors:**
- **The incident rays of the star**
- **The radiation emitted by the planet**
- **The albedo effect, which makes some of the light reflected by the planet**

The greenhouse effect (for planets with an atmosphere)

The energy generated internally by a planet due to several phenomena such as radioactive decay, tidal warming and cooling adiabatic contraction.

Cosmology.

The cosmic microwave background observed today is the most perfect black body radiation ever observed in nature, with a temperature of about 2.7 K

It was emitted at the moment of decoupling between matter and radiation in the primitive Universe.

Before that time, most of the matter in the Universe was in the form of plasma in thermal equilibrium.

According to Kondepudi and Prigogine, at a very high temperature (above 1010 K), where the thermal movement separates the protons from the neutrons despite the strong interaction, electron-positron pairs appear and disappear spontaneously and are in thermal equilibrium with electromagnetic radiation.

These particles form part of the black-body spectrum, in addition to electromagnetic radiation.

In Physics, a black body is an ideal object whose electromagnetic

spectrum depends only on the temperature.

A correct definition of the black body:

Every object in the universe has the following characteristics.

- It emits light due to its own temperature
- It reflects light from the outside a bit like a mirror
- It absorbs light from outside that helps maintain its temperature

This object is called Gray Body.

The spatial luminous power of space:

Complex synonym, but which makes it possible to analyze, by decomposing terms , the structure of the luminance.

The surface density of space flow in heavy terminology.

The fluence rate of light in learned terminology.

Synonymous light exitance used when the source is punctual.

The word emittance used when the source has a large surface and whose constant emission temperature is assumed.

The shine if it is a distant star:

Shine, which is an obsolete expression.

It's luminance term used when the light is returned by a receiver body, which becomes a transmitter and in this case, only half of the space is concerned.

Chrominance if it is a luminance with a specified color gamut.

Chrominance does not mean monochromatic, because this word refers to only 1 color, whereas chrominance refers to a range of color-shade, for example the range of reds, the range of yellows ..

Relationship between luminance and other quantities of light study:

luminance = luminous intensity-surface

luminance = irradiance-solid angle

luminance = monochromatic luminance x wavelength

luminance = brightness-surface x solid angle

luminance coefficient

Comparison of 2 luminances between 2 conditions of departure of the luminous flux

luminance factor (emitting power in light)

Comparison between the luminance re-emitted by a body and that emitted by the black body taken as reference under equivalent conditions.

As we compare luminances and they are proportional to the powers, it is easier to give yϕ in the form of a ratio of 2 powers.

The gray bodies have an emitting power yϕ independent of the wavelength (a gray body emits whitish light of low intensity)

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The sun emits its maximum wavelengths between 0.3µm and 25µm.

The moon emits wavelengths between 5µm and 50µm.

On Earth 85% of the radiation is absorbed, 15% is reflected.

On the moon it's the opposite.

The earth is a black body that is to say that the solar radiation absorbed is equal to the terrestrial radiation emitted.

All bodies radiate from the moment their temperature is above absolute 0 0 ° Kelvin (-270 ° Celsius)

The wavelength of the re-emitted radiation depends on its temperature.

Thanks to the presence of the atmosphere, the re-emitted radiation is absorbed partly by the atmosphere and again sent back to the earth.

Absorption spectra of the leaves: they absorb a large part of the radiation.

They re-emit however a small part in the visible spectrum, which explains their green color.

In ecosystems, energy transfers take many forms:

- radiative
- convective
- conductive

Or by change of state:

- liquid - solid
- solid - liquid
- liquid - gas
- gas - liquid

Black body radiation: Solid angles.

- Ray of the Moon: 1,740 km
- Distance to Moon-Land: 384,500 km
- Radius of the Sun: 7.10^5 km
- Earth-Sun Distance: 150.10^6 km

Solid angles are a generalization of plane angles to situations in space.

This notion is particularly useful in the study of radiation, this is the definition and related examples (can be considered optional if the notion is already known)

Flat surface:

Either a plane elementary surface dS, or n a vector normal to dS.

We denote R the distance from a point O to this surface.

Spherical object:

A spherical object of radius R is seen under the same solid angle as a circle of radius R at the same distance.

These two values are close.

in fact, the data provided being approximate, they are more or less close which explains in particular a annular eclipses in which the Moon occults just obscure the Sun.

The only difference with the grey body is that it reflects light while the black body absorbs absolutely all the rays incident.

The gray body is defined by the incident flux, the reflected flux, the absorbed flux, the emitted flux and the transmitted flux which characterizes the transparency of the body.

It does not interfere in the temperature of it.

To summarize, the black body has the following characteristics:

- It emits light due to its own temperature
- It absorbs light from outside that helps maintain its temperature

But this definition is not enough to characterize a black body in an exact way.

The black body must also respond to Planck's law.

Under certain conditions, it is possible to approximate a gray body to a black body because otherwise, this law would be useless.

If the luminous intensity emitted is high in front of the reflected luminous intensity of this one, then one can speak of black body.

The sun is also a black body, its surface temperature is around 6000 Kelvin (~ 5700 ° C), we can also study its electromagnetic emission curve.

A good part of its radiation is emitted in the ultraviolet which corresponds to very energetic photons therefore dangerous for us, hence the interest of protecting oneself from the sun.

The ozone layer is already doing this job very well by absorbing a good part of the energy rays.

Extraterrestrial solar radiation:

This is the radiation observed from space.

We find that it does not exactly match the spectrum of the black body.

Is it because the sun reflects a little light from elsewhere but this is a phenomenon whose influence is extremely low given the brightness of the light sources around the sun.

The sun is mostly composed of 99% hydrogen and helium and 1% other elements going up to neon.

Each element radiates in one or more specific wavelengths, this phenomenon is not obvious.

The sun is a mixture of all these elements and therefore radiates in all these wavelengths to which must be added the phenomena of equipartition of energy and tunnel effect.

The black-body model gives us valuable information about its temperature, its chemical composition and in a more detailed way allows us to study the stars that make up the sky, to classify them by categories, to trace their evolution and even to determine their distance to the Earth.

The black body is a model developed by Gustav Kirchhof in 1862 first and then Max Planck a few years later.

It has been of paramount importance in the implementation of quantum theory since this model has shown that light is composed of luminous quanta called photons having a well-defined energy and quantified and not continuous.

The physics that flows from the black body is extremely vast.

Writing about the black body model without discussing spectral lines, electron-photon interactions and Maxwell's distribution of thermodynamic equilibrium velocities is not really balanced.

The cosmic microwave background.

Cosmic Microwave Background (CMB) is the name given to a very homogeneous electromagnetic radiation observed in all directions of the sky and whose peak emission is located in the field of microwaves.

Discovered by chance in 1964, the CMB allows the scientific community to separate the various cosmological models, in particular by abandoning the models based on the perfect cosmological principle and by prioritizing the models based on the idea of Big Bang, which predict the emission of such thermal radiation at the time of the primordial Universe.

According to the standard model of cosmology, this fossil radiation was emitted around 380,000 years after the Big Bang, when the Universe was both much smaller, dense and hot. I

t was then diluted and cooled by the expansion of the Universe and now has a very low average temperature, of the order of 3 Kelvin (K)

The CMB is a very studied physical phenomenon for two reasons: it corresponds to the oldest electromagnetic image that can be obtained from the Universe and it presents minute variations of temperature and intensity according to the observed direction, detailed anisotropies since the beginning of the 1990s that collect a lot of information on the structure, age and evolution of the Universe.

Angular scales:

Following the discovery of CMB, hundreds of studies have been conducted to characterize it.

For example, an Italian-American collaboration, begun in 1979 and continued until at least 1984, confirms that the CMB is behaving like a black body.

Shortly thereafter, a collaboration between ESO and MIT confirms that the CMB comes from a cosmological phenomenon and not from a celestial object.

NASA's Cosmic Background Explorer (COBE) mission, conducted from 1989 to 1996, detects and quantifies large scale anisotropies.

The fossil radiation is made of all the photons that have been emitted during the opacity-transparency transition and that have been propagated freely since.

These are the oldest photons in the Universe.

They are the age of the universe minus a million years.

Hubert Reeves, 1988.

Update

Posted by Veronica IN DREAM at 2:57 PM