ELECTROMAGNETIC RADIATION

1. Types of electromagnetic radiation

Use different resources to sort the types of electromagnetic radiation according to rising wavelength, find sources, uses and mention if an overdose is/is not harmful.

radio waves, X-rays, infrared radiation, microwaves, light, gamma rays, ultraviolet radiation
http://en.wikipedia.org/wiki/Electromagnetic_spectrum

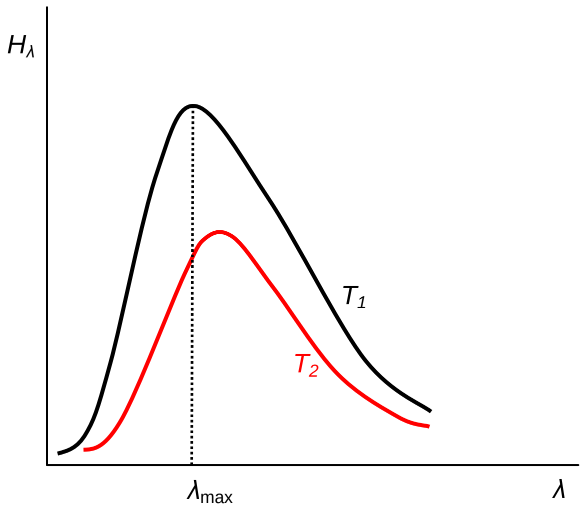
type of elmag. wave	source	use	danger

TENTO PROJEKT JE SPOLUFINANCOVÁN EVROPSKÝM SOCIÁLNÍM FONDEM A STÁTNÍM ROZPOČTEM ČESKÉ REPUBLIKY

2. Black body radiation

BB = ideal object, which absorbs ALL the radiation of any λ falling on it and emits the radiation which depends ONLY on its TEMPERATURE

sketch BB:



T_1 T_2 add: is bigger or smaller

H_λ ... energy emitted from 1m^2 of the inner area during one second

- for higher T energy emitted at any wavelength is bigger
- even at 1000 K a very low amount of light is produced
- Stefan's law:
  The total energy radiated of all wavelengths per unit area per unit time by a BB is proportional to the fourth power of its thermodynamic temperature

  $E = \sigma T^4$

  $E = \text{area} \times \text{time} \times \sigma T^4$

  $\sigma = 5.7\times10^{-8}\ \text{W}\cdot\text{m}^{-2}\cdot\text{K}^{-4}$ Stefan constant

- non-black body radiation

  $E = \varepsilon\sigma T^4$

  ε ... emissivity, less than 1 for non-black body

- Wien's displacement law

  $\lambda_{max} T = b$

  $b = 2.9\times10^{-3}\ \text{m}\cdot\text{K} = \text{const.}$ Wien constant

- quantized energy of electromagnetic radiation

  Planck (1900):
  Energy of electromagnetic radiation is released or absorbed only in multiples of some smallest amounts of energy = energy of a quantum E_q

  $E_q = hf$ $\quad h = 6.625 \times 10^{-34}\,\mathrm{J \cdot s}$ Planck constant

http://www.mhhe.com/physsci/astronomy/applets/Blackbody/frame.html
http://www.astro.ufl.edu/~oliver/ast3722/lectures/BasicDetectors/DetectorBasics.htm
http://en.wikipedia.org/wiki/Black_body

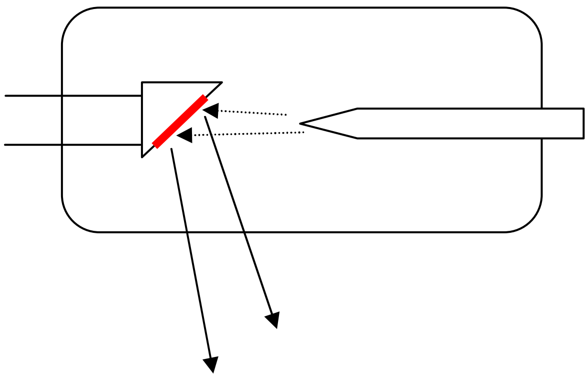
Questions:
1. Why do we have indoor and outdoor coloured films (setup for cameras)?
2. Which quantity corresponds to the area under the BB emission graph? How is it related to the temperature of BB?
3. Tungsten is used to make filament lamps, its melting point is 3 380 °C. Why is it used?
4. The Sun emits the maximum amount of energy at 500 nm. Assuming that it is a BB, calculate its surface temperature.
5. BB, T = 2 000 K, A = 0.5 m^2

a) At which wavelength is the maximum amount of energy emitted?
b) How much total energy is emitted in a minute?
c) What is the energy of a quantum at λ_{max}
d) How many quanta of λ_{max} represent energy of 1 mJ?

L6/147

3. X-rays

- source – X-ray tube



- principle – electrons (1) produced by thermionic emission on cathode (2) are accelerated towards anode (3); as they hit the target (4) about 0.5% of their E_k is converted into the X-rays (5)

Label the parts of the X-ray tube with the numbers from the previous text.

- intensity – number of e (current)

- λ - speed of e – voltage, affects the penetrating power

- properties

1. travel in straight lines
2. penetrate materials (λ)
3. are not deflected in el. or mag. field (as they are short wavelength elmag. radiation)
4. can eject e from matter by photoelectric emission
5. can ionize gas
6. cause fluorescence of suitable substances
7. affect a photographic layer/plate

- uses

1. medicine – radiographs (=X-ray photographs) – penetrate muscles but not bone
2. industry – inspections of internal imperfections – welded joints, materials, ...
3. X-ray crystallography – diffraction on a crystal lattice – structure of materials (typical patterns)

http://cz7asm.wz.cz/fyz/index.php?page=renzar

4. Photometry

Photometry deals with the measurement of visible light as perceived by human eyes.

Luminous intensity *(I)* – physical quantity – is a measure of the wavelength-weighted power emitted by a light source in a particular direction per unit solid angle.

Candela *(cd)* – an SI base unit
= luminous intensity of a source that emits monochromatic green light with a frequency of 540 THz (540×10^{12} Hz) in a given direction and that has a radiant intensity in this direction of 1/683 watts per steradian.
Example: A common candle emits light with roughly 1 cd luminous intensity. (100 W bulb – 135 cd, LED – 0.005 cd, photoflash – 1000000 cd).

Luminous flux *(ΔΦ)* – physical quantity – is the total perceived power emitted in all directions. (*Attention:* Luminous intensity is the perceived power per unit solid angle. Luminous intensity is also not the same as the radiant intensity, the corresponding objective physical quantity, used in radiometry)

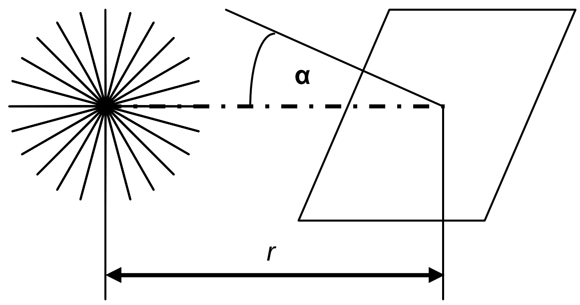
Lumen *(lm)* – the SI derived unit
= luminous flux emitted uniformly by a point light source of luminous intensity one candela across a solid angle of one steradian.
(Alternatively, an isotropic one-candela light-source emits a total luminous flux of exactly 4π lumens ≈ 12.6 lm.)

Illuminance *(E)* – physical quantity – is the total luminous flux incident on a surface, per unit area. It is a measure of the intensity of the incident light.

Lux *(lx)* – the SI derived unit
= illuminance produced by luminous flux of one lumen falling uniformly and perpendicularly on a surface one meter square.

$$E = \frac{\Delta \Phi}{\Delta A}$$

$$E = \frac{I \cos \alpha}{r^2}$$



Questions:
L6/136-139, 141-142

Answers:
4. 6 073 ℃
5. 1.45 µm
27.36 MJ
1.37×10^{-19} J
7.3×10^{15}