

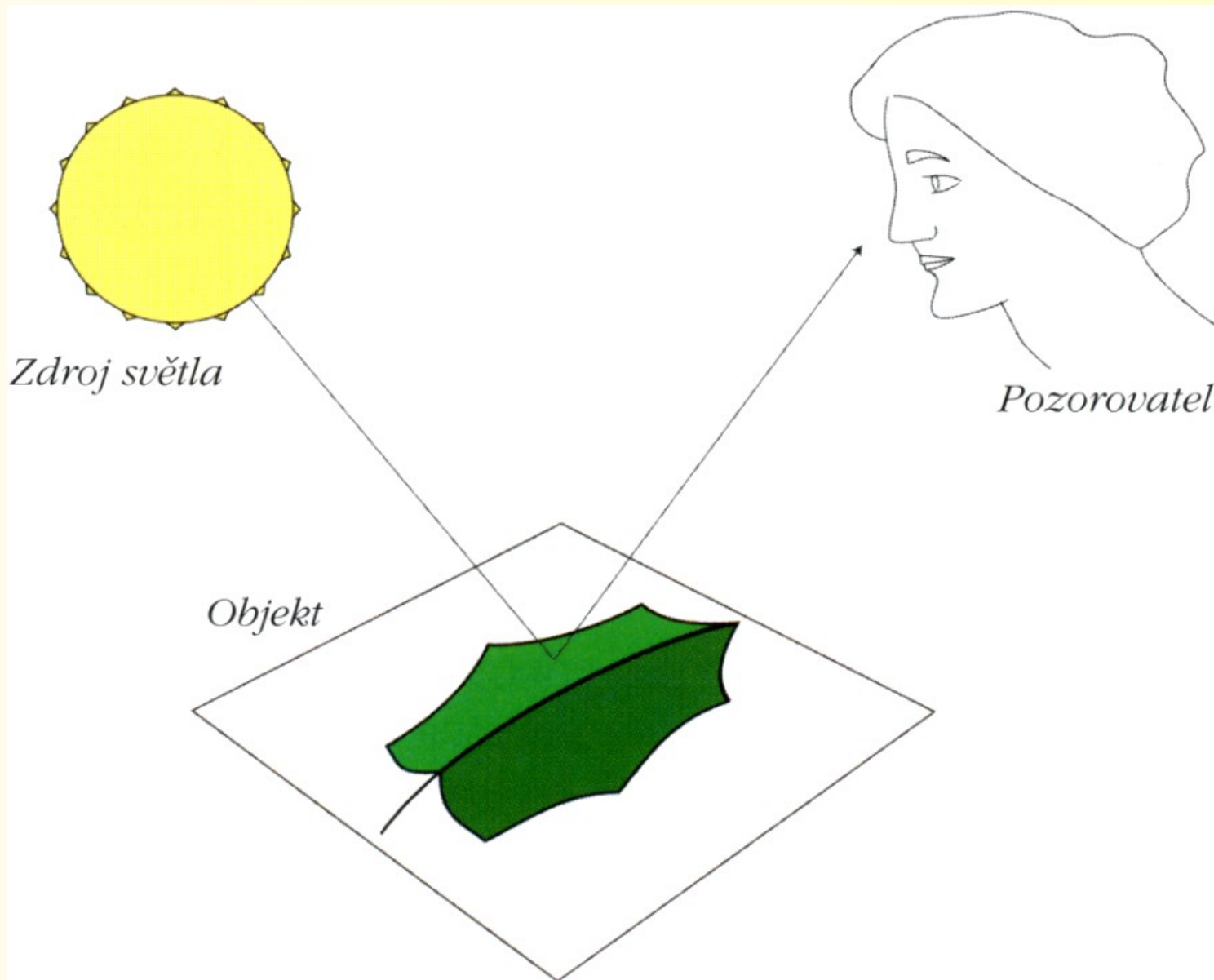
Fyzika v digitální fotografii

Část 1: Zdroje světla

Stanislav Hledík

`stanislav.hledik@fpf.slu.cz`

Zdroj – (šíření – objekt – šíření) – detekce



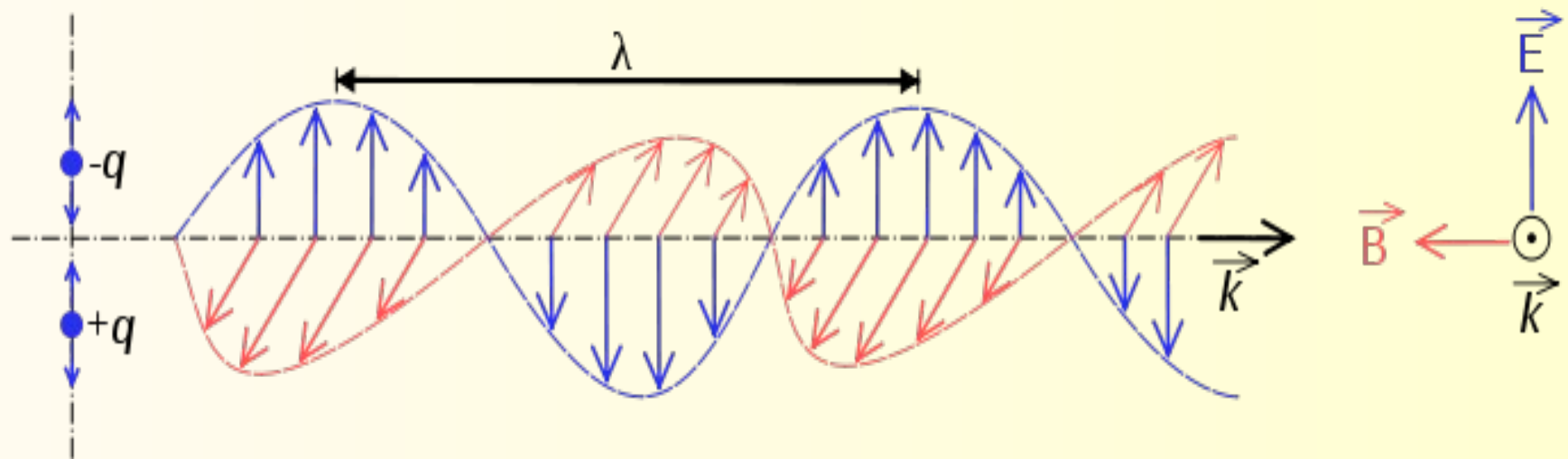
Maxwellovy rovnice a vlnové řešení

$$\nabla \cdot \mathbf{D} = 4\pi \rho_f$$

$$\nabla \times \mathbf{E} = -\frac{1}{c} \frac{\partial \mathbf{B}}{\partial t}$$

$$\nabla \cdot \mathbf{B} = 0$$

$$\nabla \times \mathbf{H} = \frac{1}{c} \frac{\partial \mathbf{D}}{\partial t} + \frac{4\pi}{c} \mathbf{J}_f$$



Kvantové vlastnosti

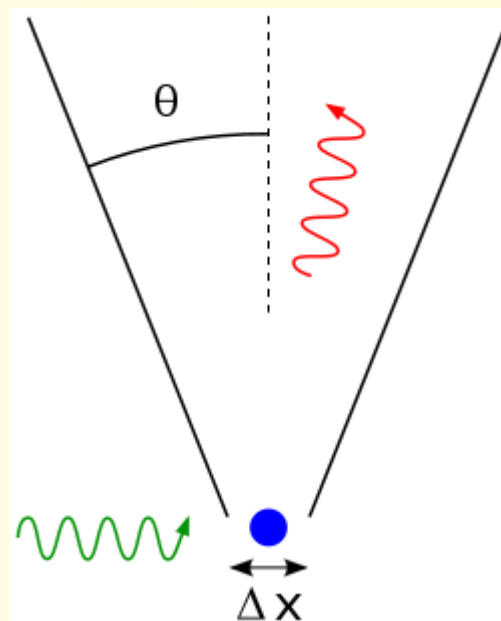
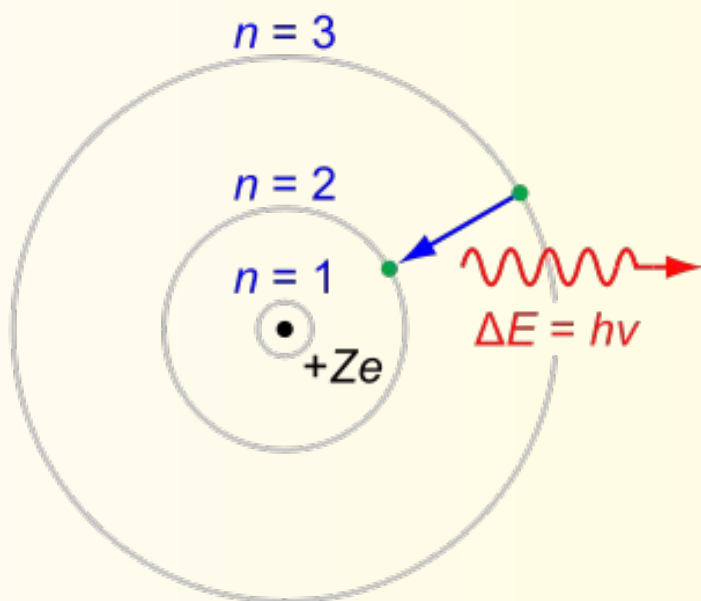
Fotony -

Planckův-Einsteinův vztah

$$E = hf$$

Emise/absorpce

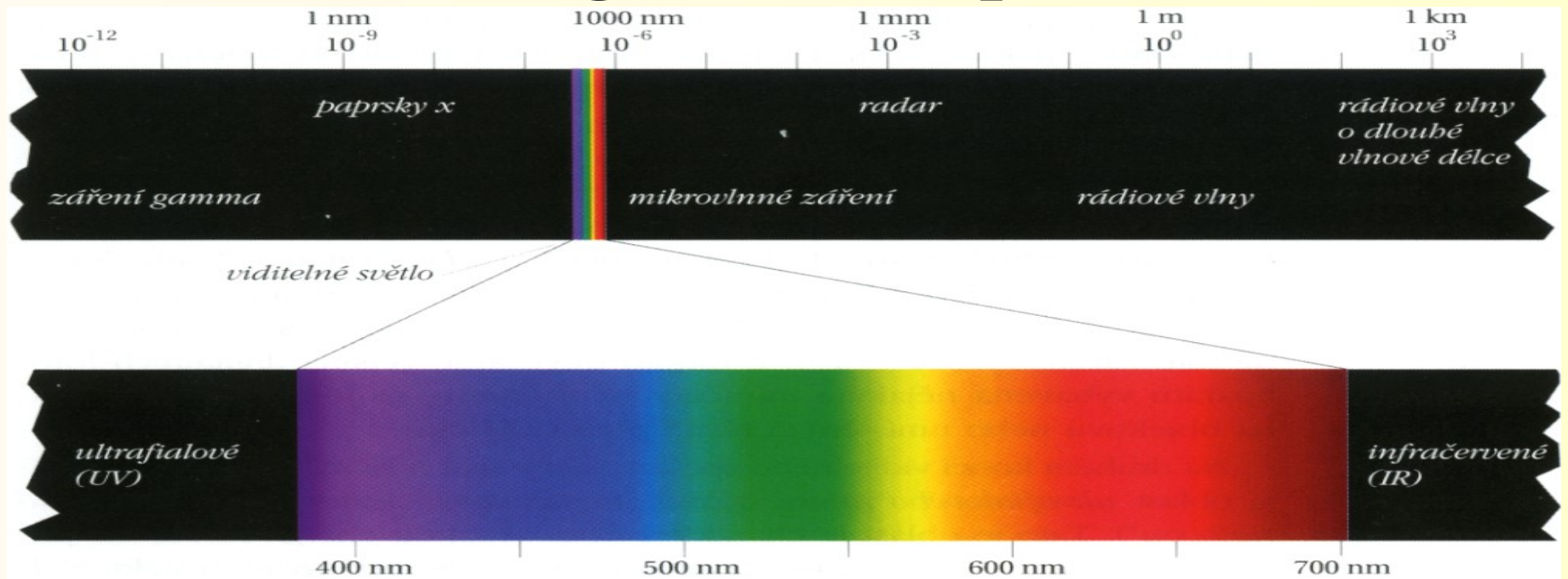
Heisenbergův princip neurčitosti



$$\Delta x \Delta p \geq \frac{\hbar}{2}$$

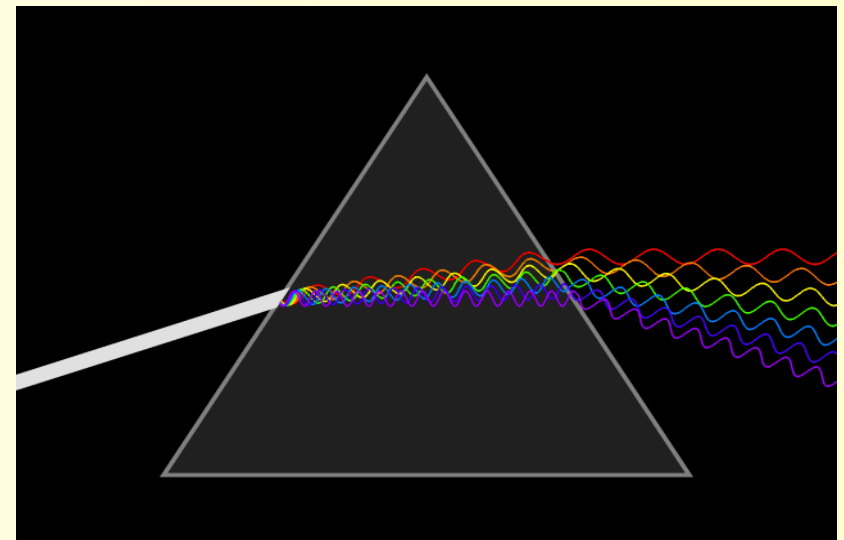
<http://en.wikipedia.org/wiki/Photon>

Elektromagnetické spektrum

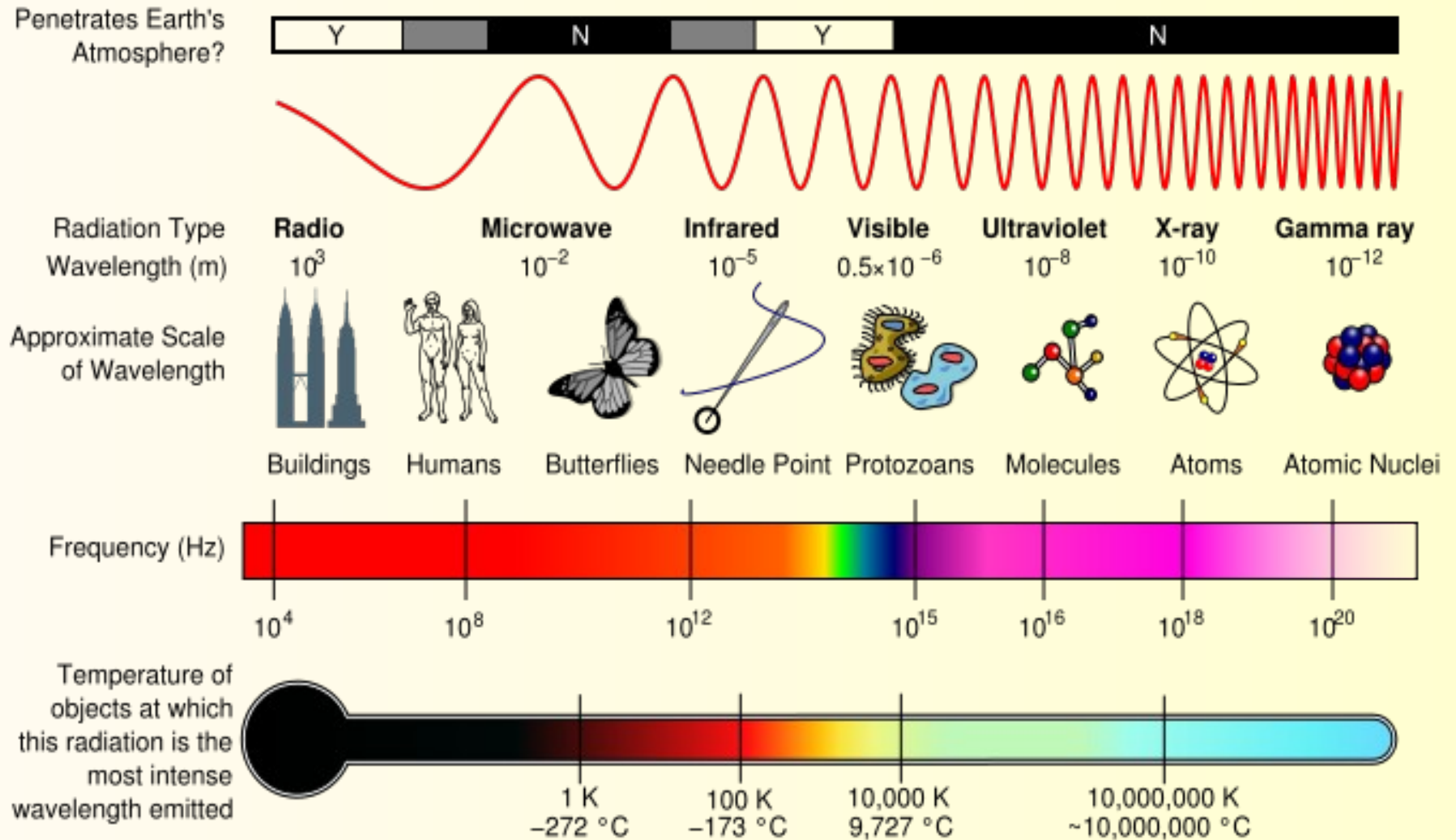


CLASS	FREQUENCY	WAVELENGTH	ENERGY
Y	300 EHz	1 pm	1.24 MeV
HX	30 EHz	10 pm	124 keV
SX	3 EHz	100 pm	12.4 keV
EUV	300 PHz	1 nm	1.24 keV
NUV	30 PHz	10 nm	124 eV
NIR	3 PHz	100 nm	12.4 eV
MIR	300 THz	1 μ m	1.24 eV
FIR	30 THz	10 μ m	124 meV
EHF	3 THz	100 μ m	12.4 meV
SHF	300 GHz	1 mm	1.24 meV
UHF	30 GHz	1 cm	124 μ eV
VHF	3 GHz	1 dm	12.4 μ eV
HF	300 MHz	1 m	1.24 μ eV
MF	30 MHz	10 m	124 neV
LF	3 MHz	100 m	12.4 neV
VLF	300 kHz	1 km	1.24 neV
VF/ULF	30 kHz	10 km	124 peV
SLF	3 kHz	100 km	12.4 peV
ELF	300 Hz	1 Mm	1.24 peV
	30 Hz	10 Mm	124 feV
	3 Hz	100 Mm	12.4 feV

optika

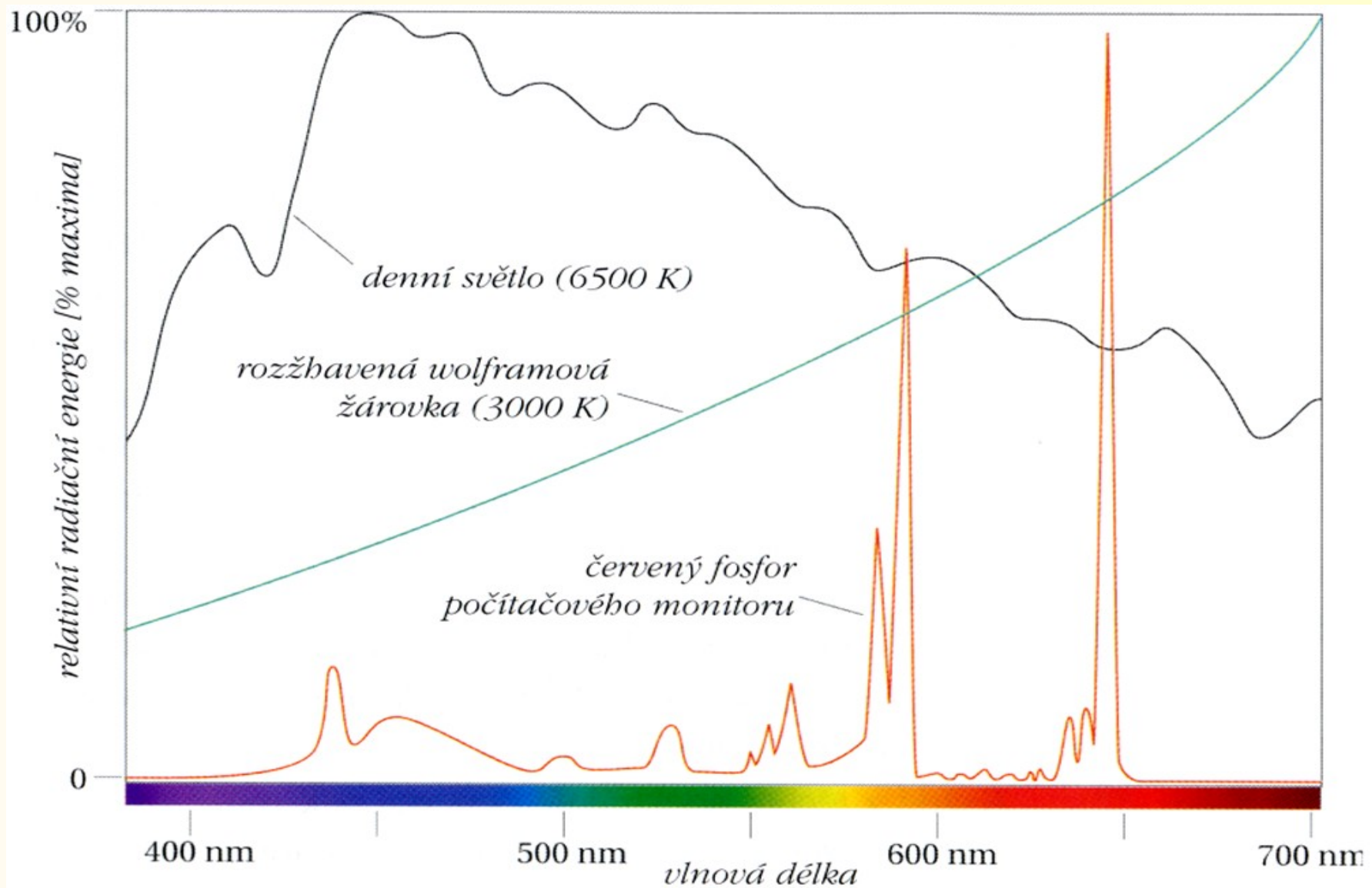


Elektromagnetické spektrum

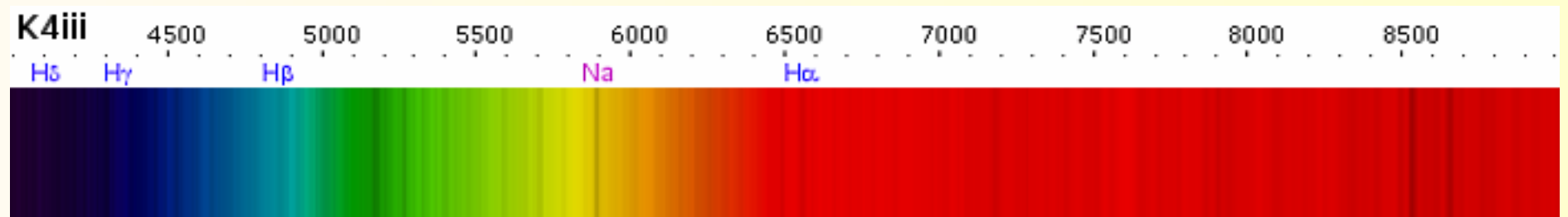
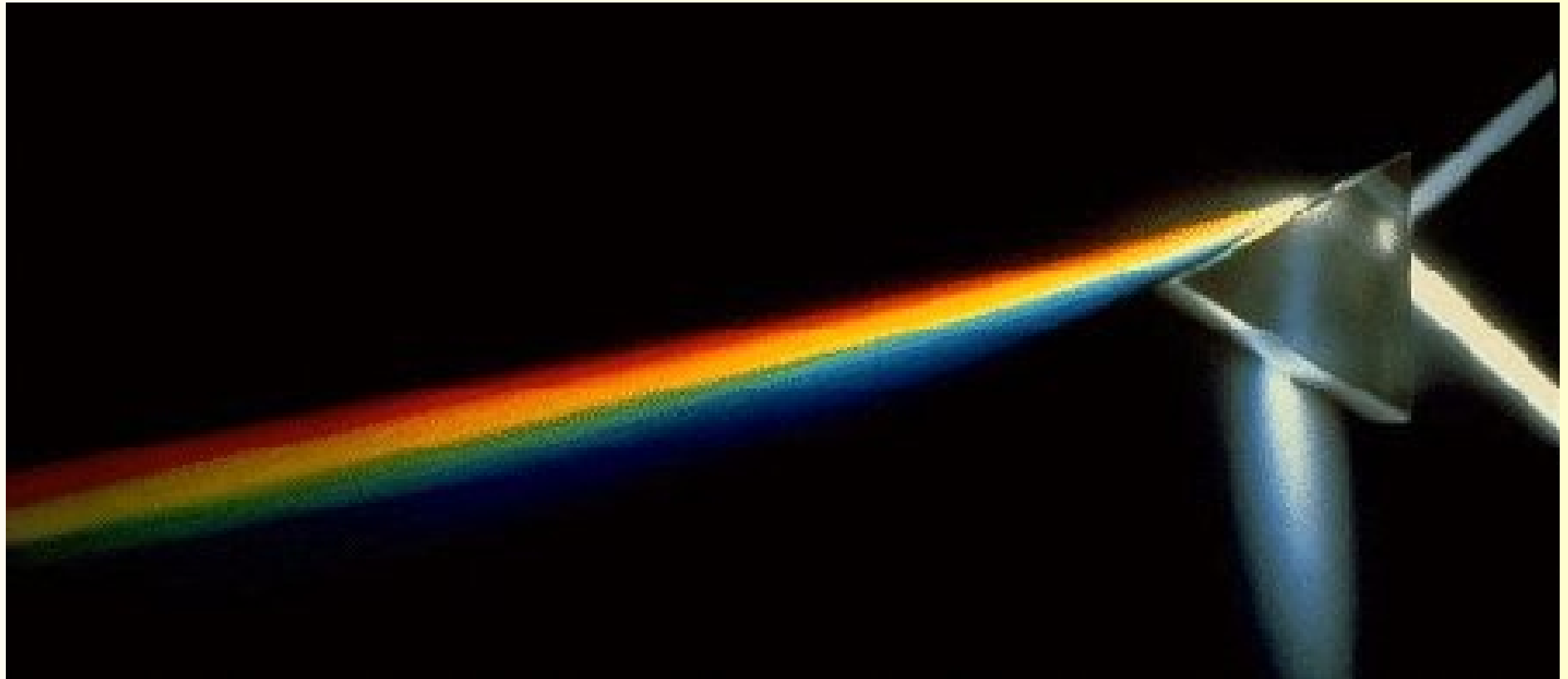


http://en.wikipedia.org/wiki/Electromagnetic_spectrum

Příklady spekter

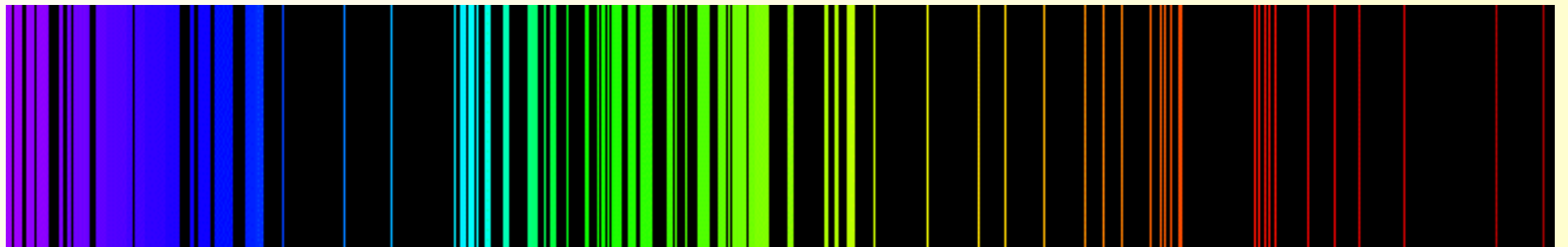
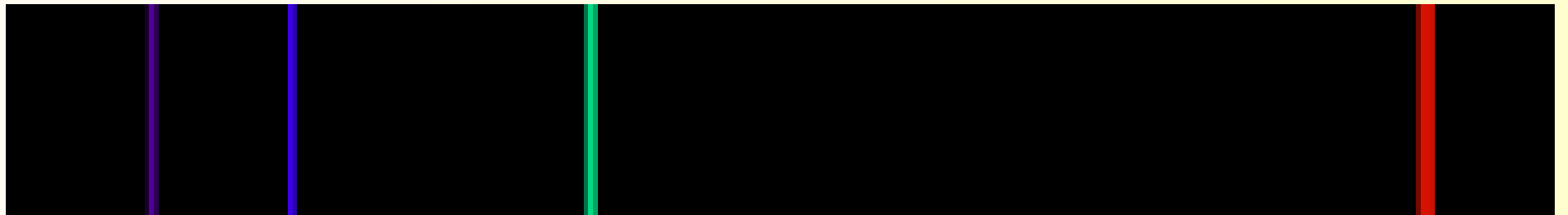
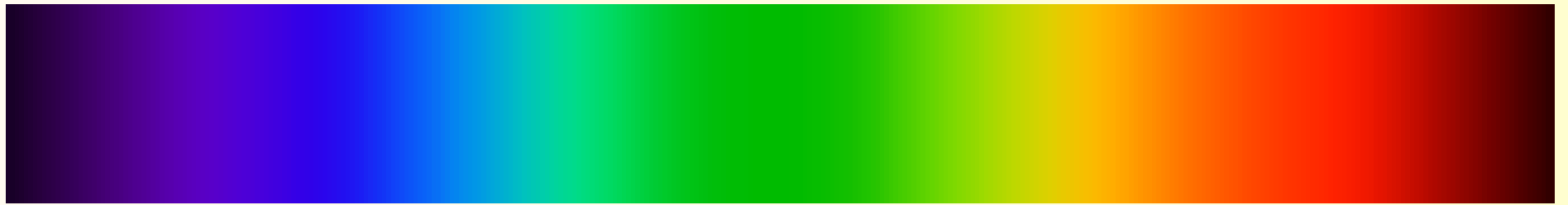


Rozklad světla

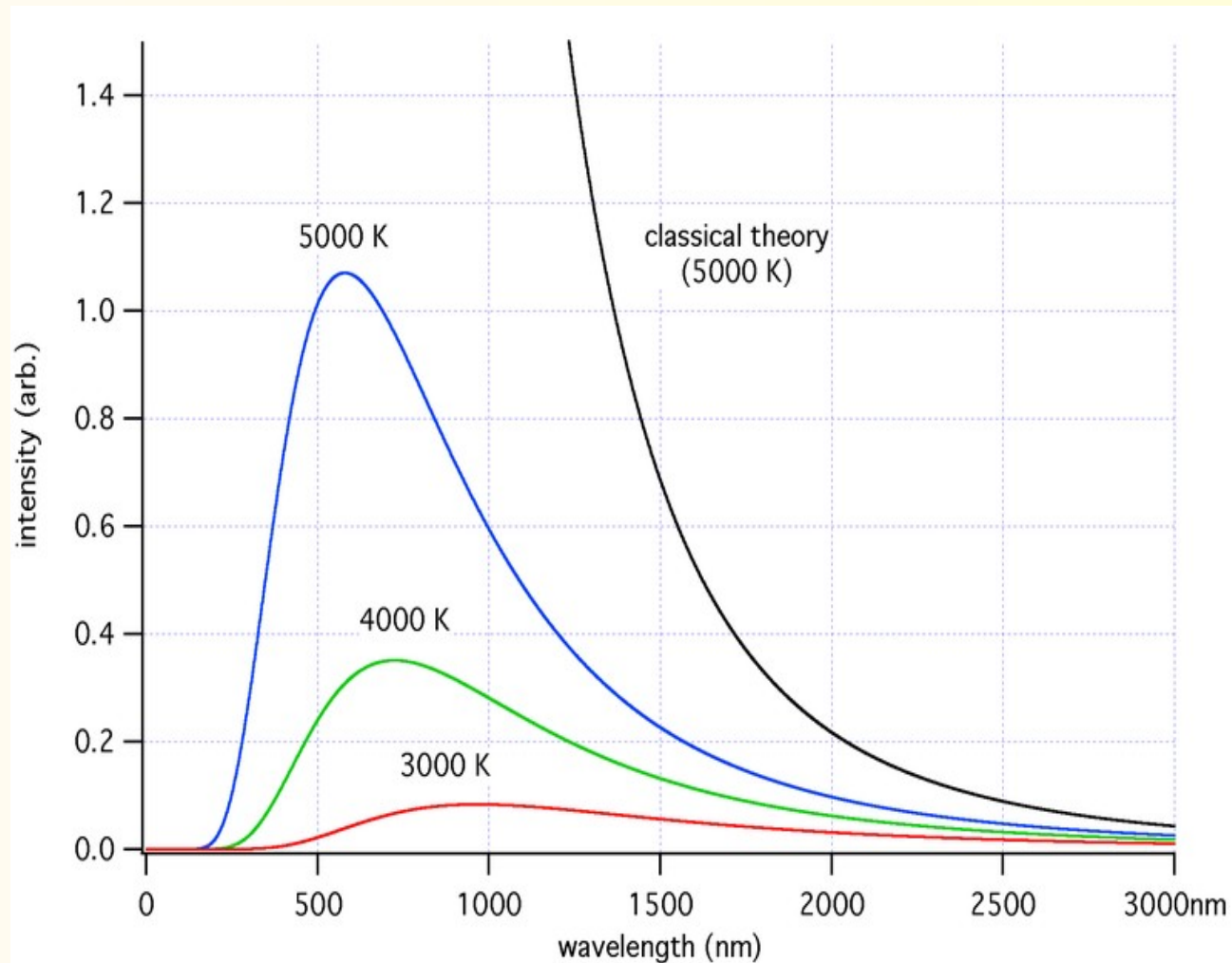


[http://en.wikipedia.org/wiki/Dispersion_\(optics\)](http://en.wikipedia.org/wiki/Dispersion_(optics))

Spojité, emisní, absorpční spektrum



Záření černého tělesa



$$I'(\lambda, T) = \frac{2hc^2}{\lambda^5} \frac{1}{e^{\frac{hc}{\lambda kT}} - 1}$$

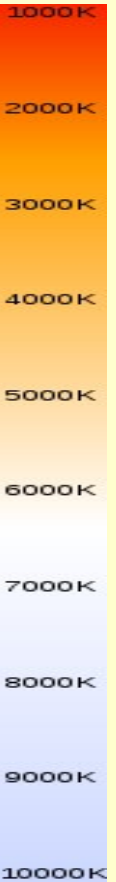
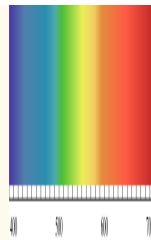
$$I(\nu, T) = \frac{2h\nu^3}{c^2} \frac{1}{e^{\frac{h\nu}{kT}} - 1}$$

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

$$\nu_{\max} = \frac{2.821}{h} kT$$

$$j^* = \sigma T^4,$$

$$P_{\text{net}} = A\sigma\epsilon (T^4 - T_0^4)$$



<http://en.wikipedia.org/wiki/Blackbody>

Záření černého tělesa



Záření černého tělesa



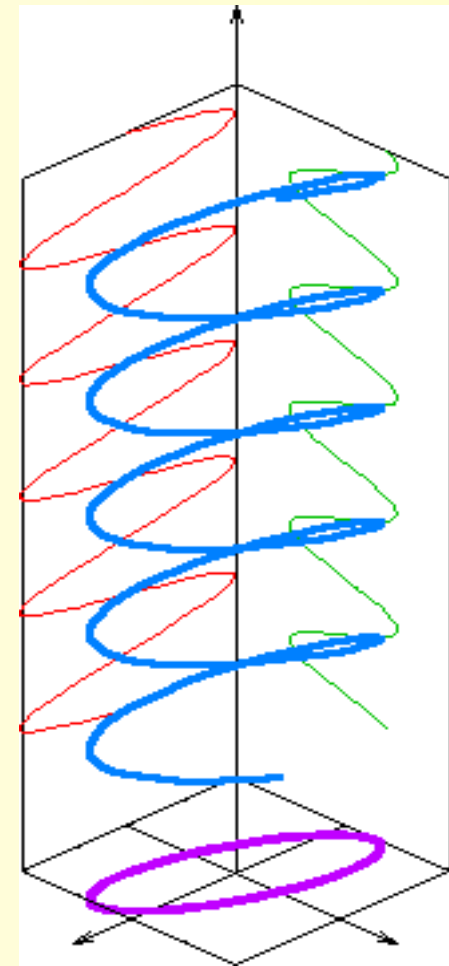
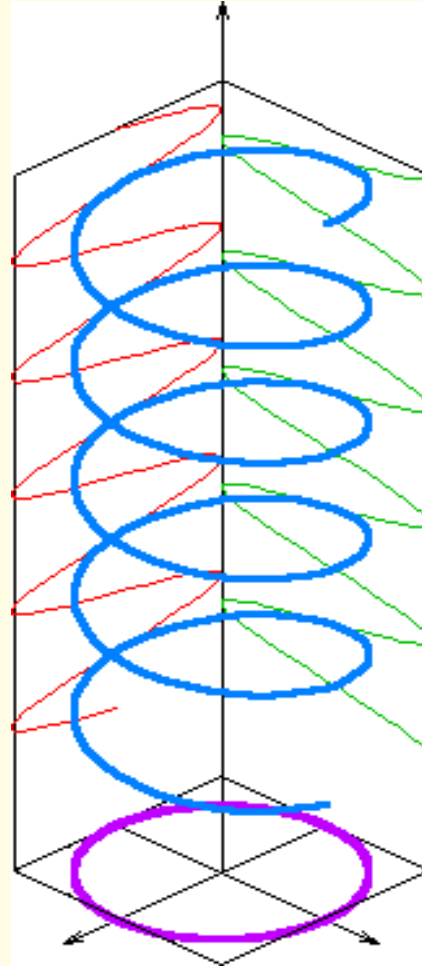
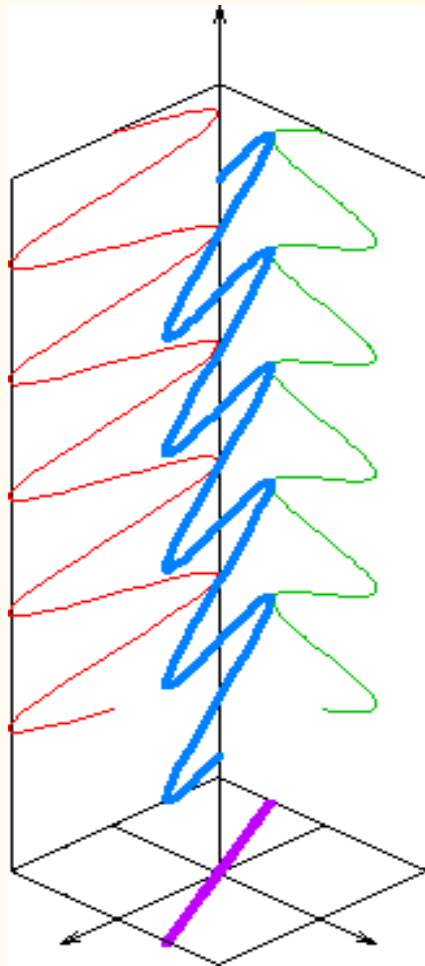
Radiometrie vs. fotometrie

Quantity	Symbol	SI unit	Abbr.	Notes
Radiant energy	Q	joule	J	energy
Radiant flux	Φ	watt	W	radiant energy per unit time, also called <i>radiant power</i>
Radiant intensity	I	watt per steradian	$W \cdot sr^{-1}$	power per unit solid angle
Radiance	L	watt per steradian per square metre	$W \cdot sr^{-1} \cdot m^{-2}$	power per unit solid angle per unit <i>projected</i> source area. called <i>intensity</i> in some other fields of study.
Irradiance	E, I	watt per square metre	$W \cdot m^{-2}$	power incident on a surface. sometimes confusingly called " <i>intensity</i> ".

Quantity	Symbol	SI unit	Abbr.	Notes
Luminous energy	Q_v	lumen second	lm·s	units are sometimes called <i>talbots</i>
Luminous flux	F	lumen (= cd·sr)	lm	also called <i>luminous power</i>
Luminous intensity	I_v	candela (= lm/sr)	cd	an <i>SI base unit</i>
Luminance	L_v	candela per square metre	cd/m ²	units are sometimes called "nits"
Illuminance	E_v	lux (= lm/m ²)	lx	Used for light <i>incident</i> on a surface
Luminous emittance	M_v	lux (= lm/m ²)	lx	Used for light emitted from a surface
Luminous efficacy		lumen per watt	lm/W	ratio of luminous flux to <i>radiant flux</i>

<http://en.wikipedia.org/wiki/Radiometry>

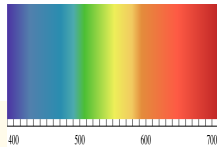
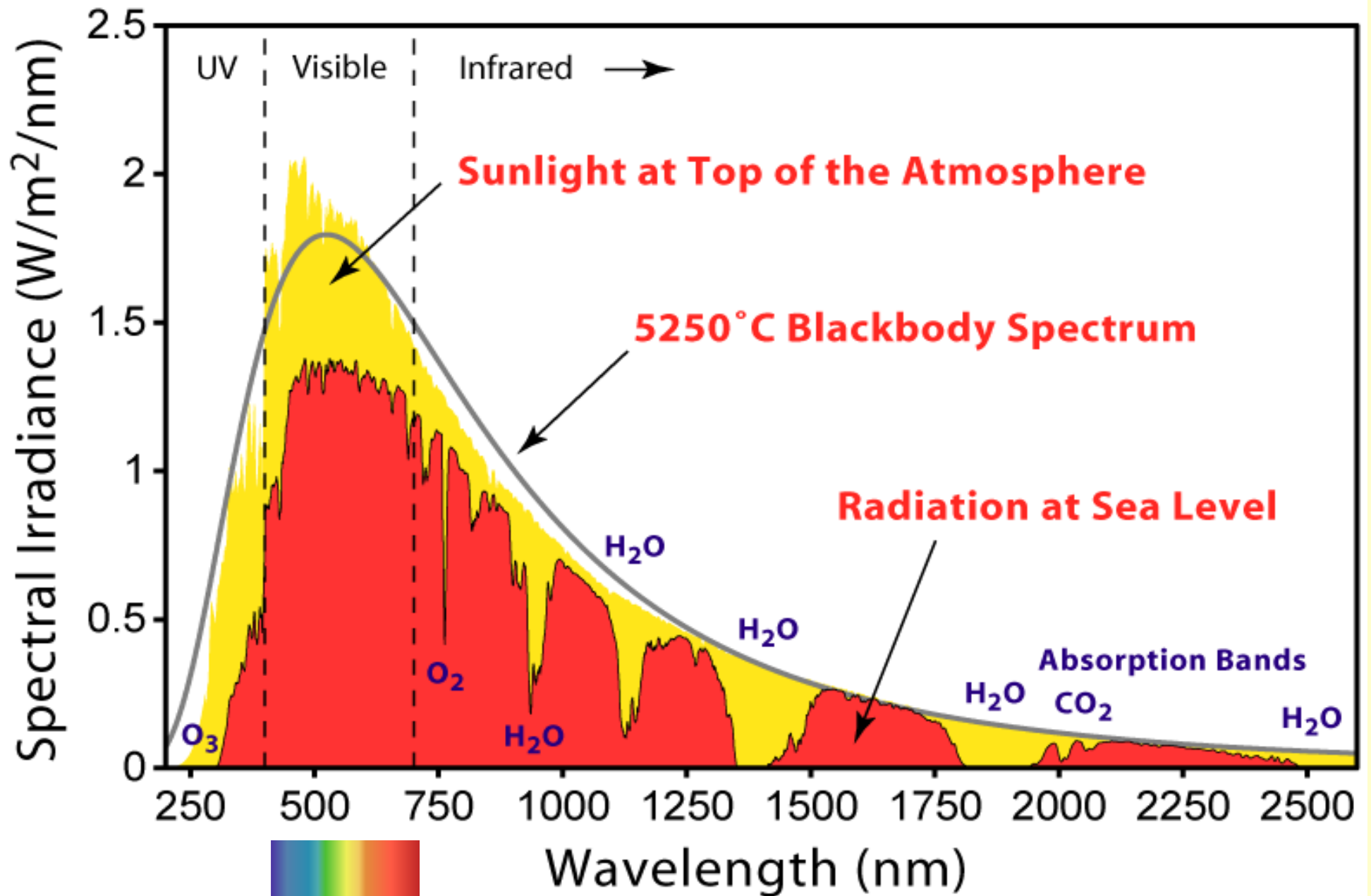
Polarizace světla



$$\vec{E}(\vec{r}, t) = (A_x \cdot \cos(kz - \omega t), A_y \cdot \cos(kz - \omega t + \phi), 0)$$

<http://en.wikipedia.org/wiki/Polarization>

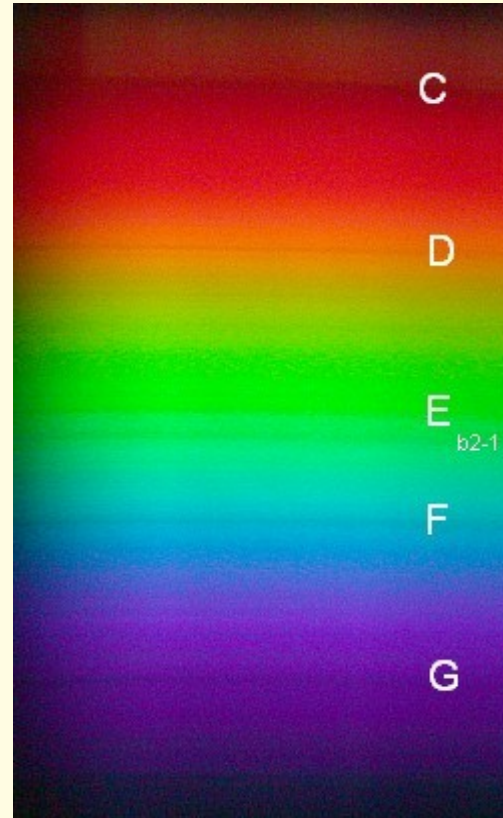
Slunce



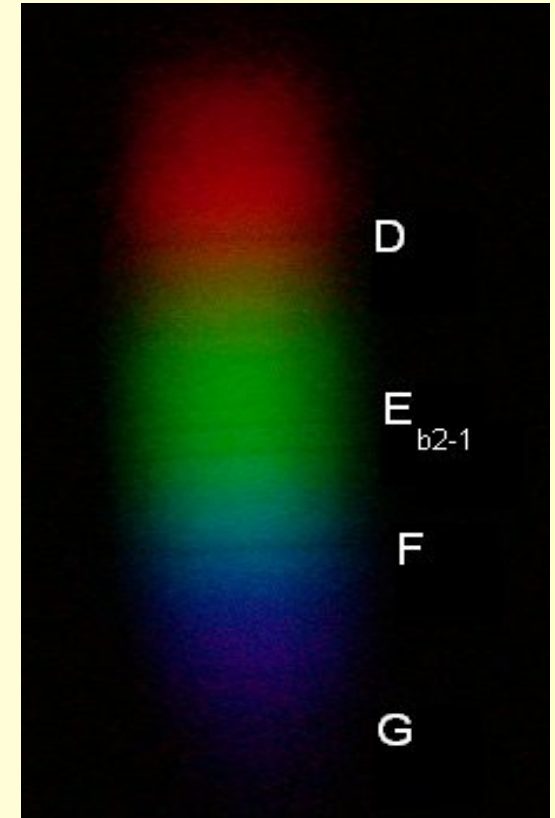
Měsíc



0.2-1 lx



Slunce

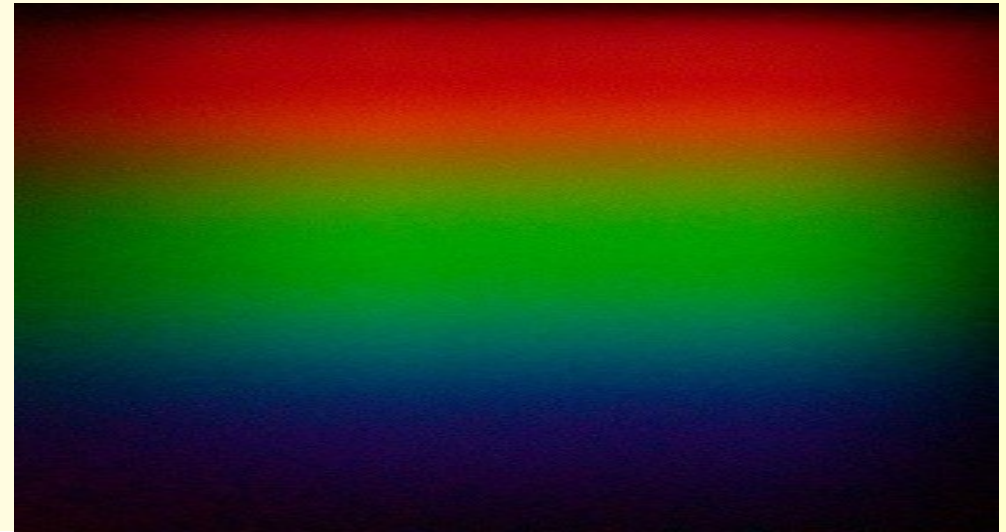


Měsíc

<http://en.wikipedia.org/wiki/Sunlight>

<http://www.cs.cmu.edu/~zhuxj/astro/html/spectrometer.html>

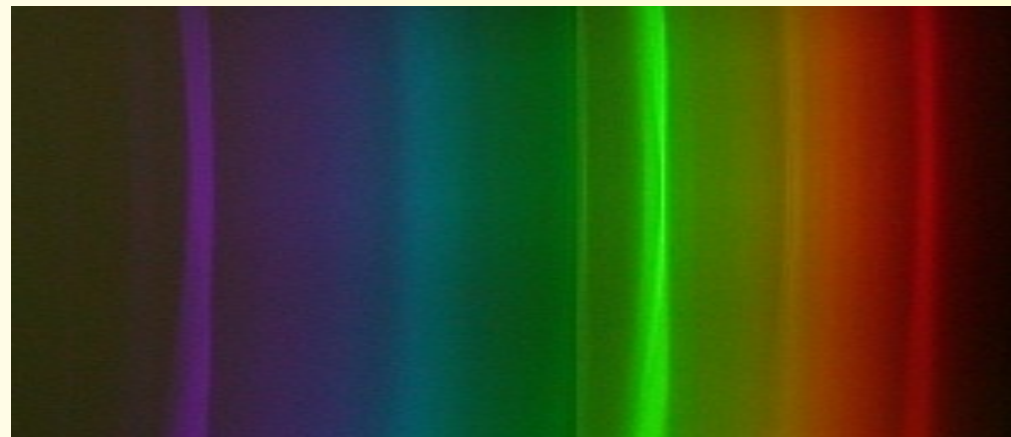
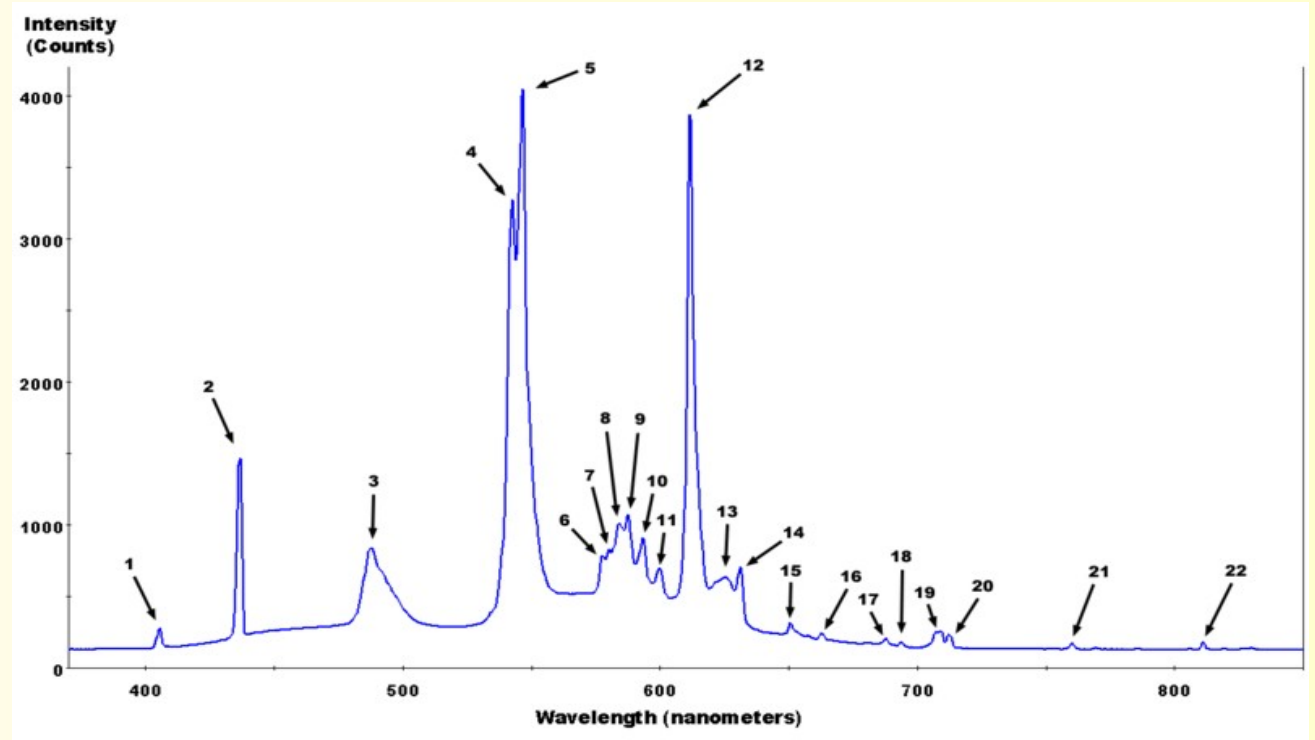
Žárovka



Type	Overall luminous efficiency
40 W tungsten incandescent	1.9%
60 W tungsten incandescent	2.1%
100 W tungsten incandescent	2.6%
glass halogen	2.3%
quartz halogen	3.5%
high-temperature incandescent	5.1%
ideal black-body radiator at 4000 K	7.0%
ideal black-body radiator at 7000 K	14%
ideal monochromatic 555 nm (green) source	100%

http://en.wikipedia.org/wiki/Light_bulb

Fluorescenční lampa alias zářivka

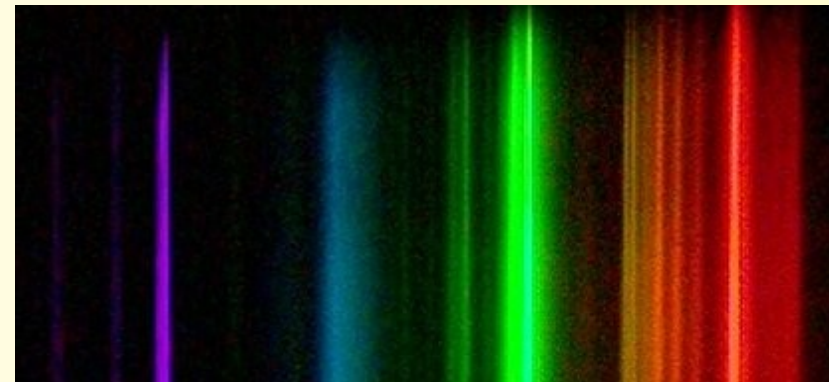


http://en.wikipedia.org/wiki/Fluorescent_lamp

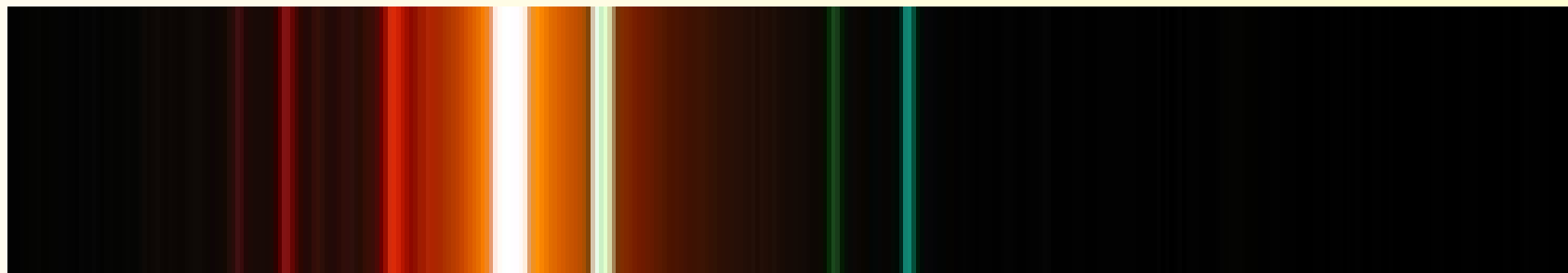
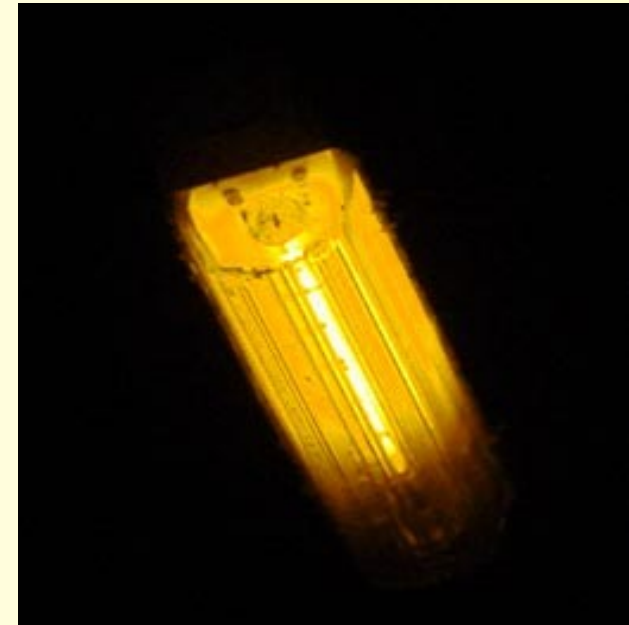
Kompaktní fluoresc. lampa (CFL)



Color temperature	kelvin	mired
'Warm white' or 'Soft white'	≤ 3000 K	≥ 333 M
'White' or 'Bright White'	3500 K	286 M
'Cool white'	4000 K	250 M
'Daylight'	≥ 5000 K	≤ 200 M

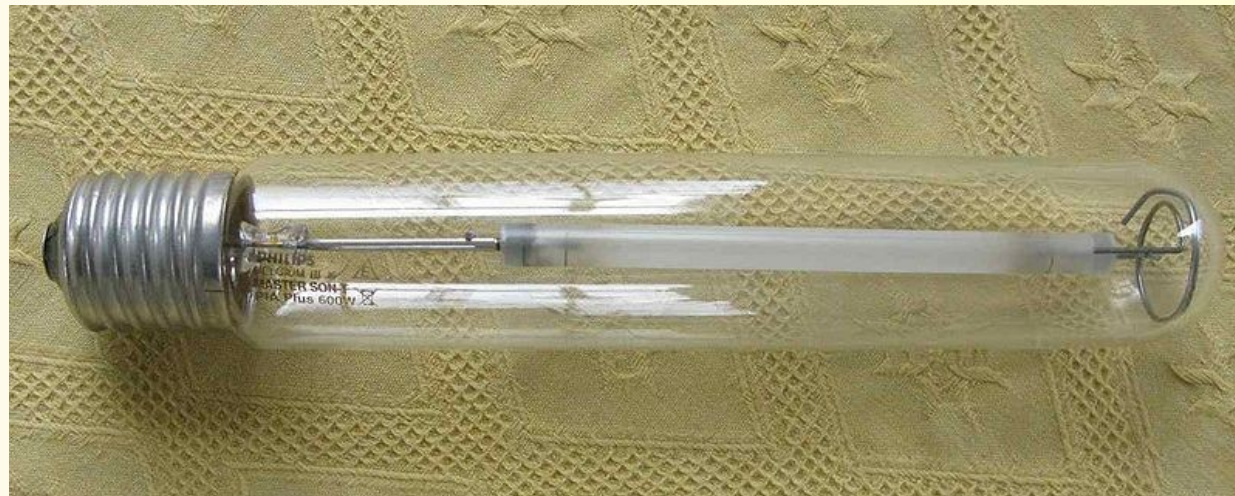
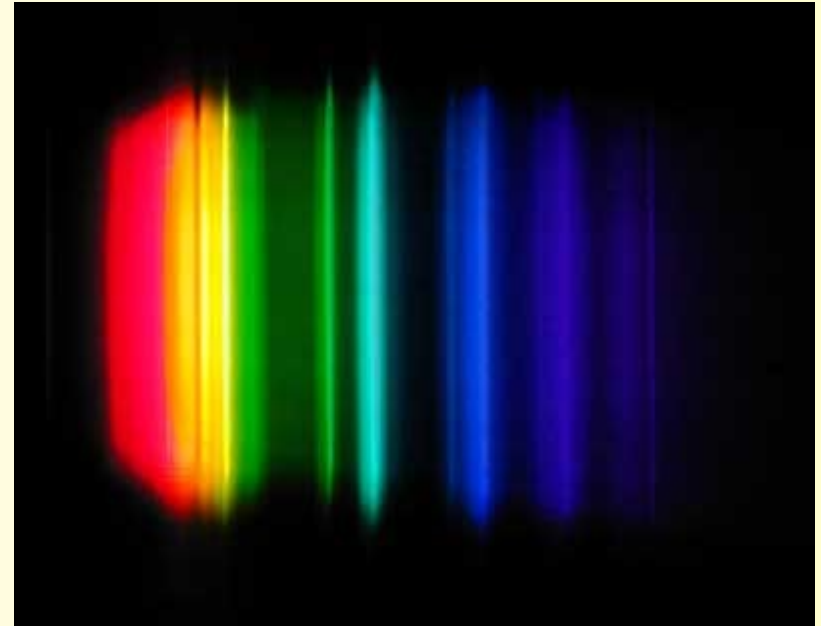


Nízkotlaké Na výbojky (LPS/SOX)



http://en.wikipedia.org/wiki/Sodium_vapor_lamp

Vysokotlaké Na výbojky (HPS)



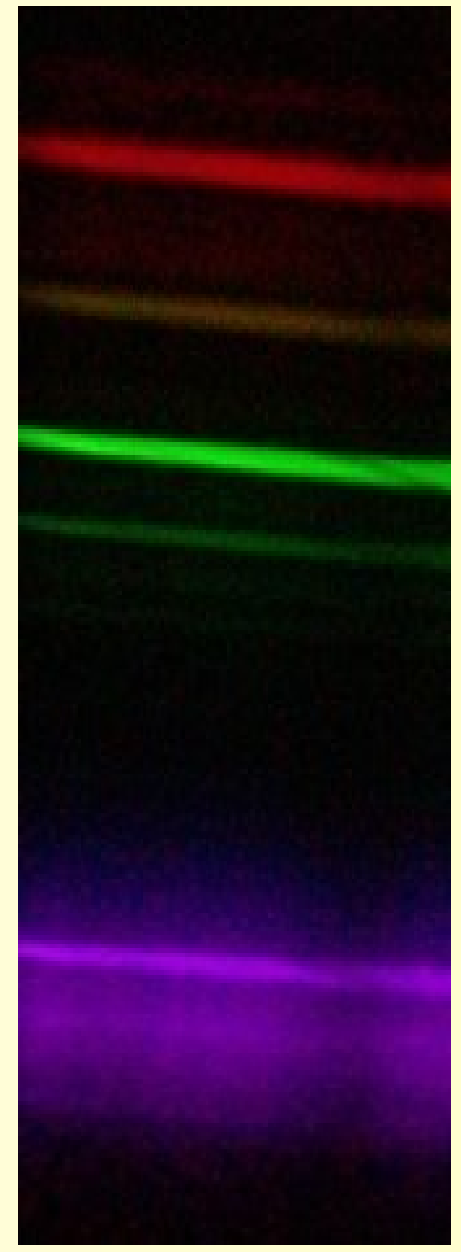
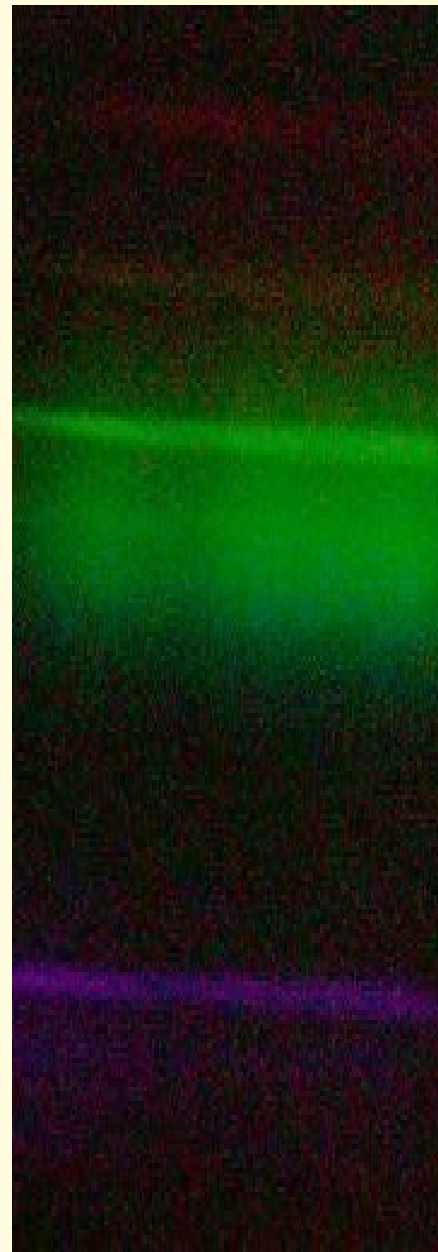
Rtuťové výbojky



Wavelength (nm)	Name (see Photoresist)
253.7	
365.4	I-line
404.7	H-line
435.8	G-line
546.1	
578.2	

http://en.wikipedia.org/wiki/Mercury-vapor_lamps

Neonové, argonové, ... lampy



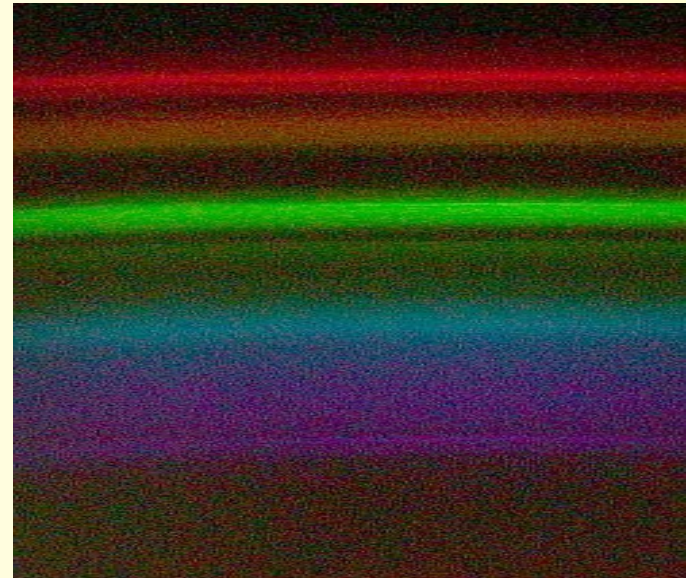
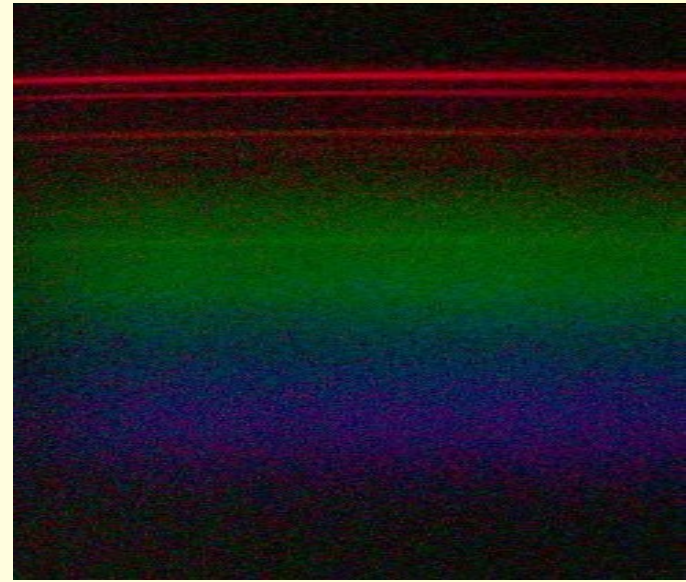
http://en.wikipedia.org/wiki/Neon_tube

Oheň...



<http://www.cs.cmu.edu/~zhuxj/astro/html/spectrometer.html>

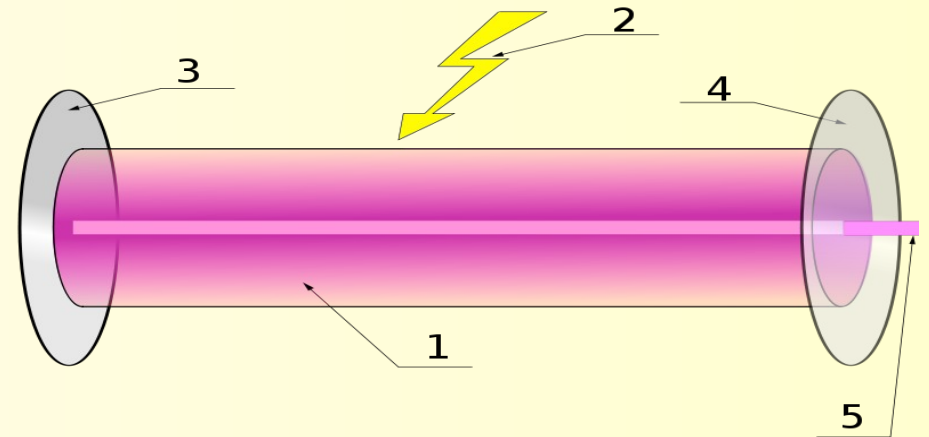
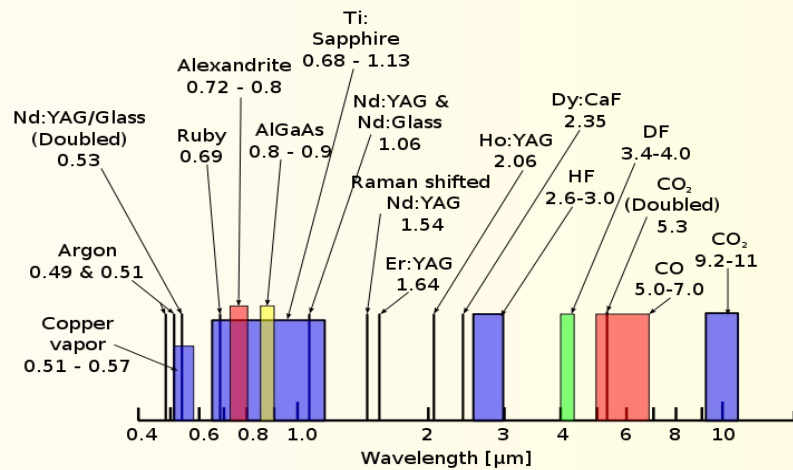
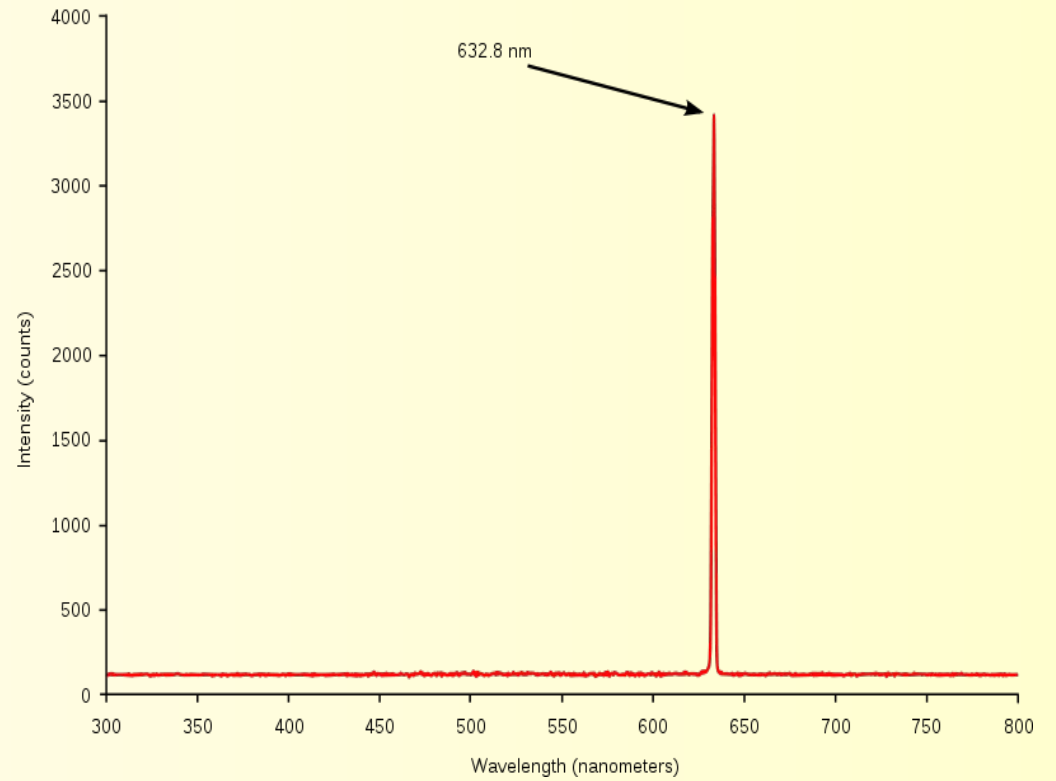
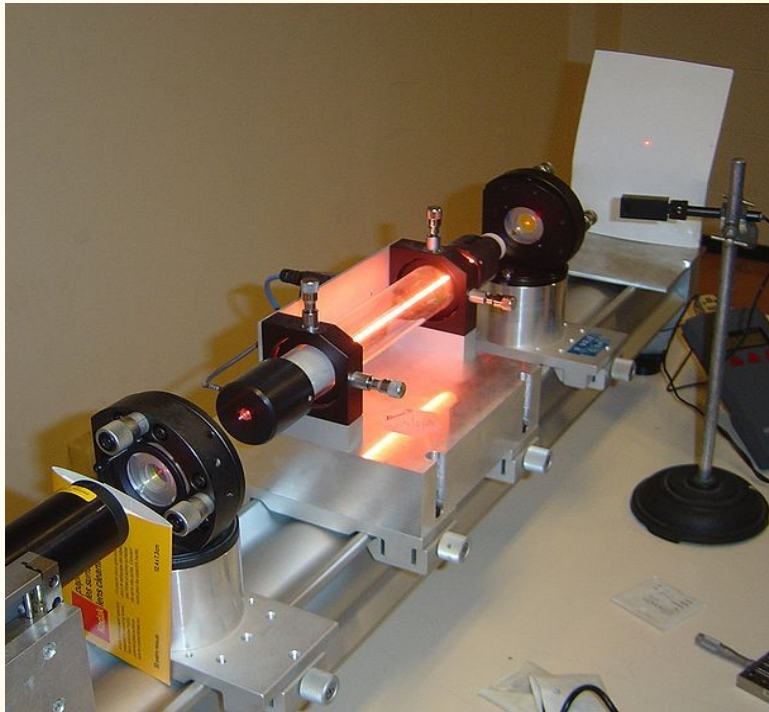
Monitory: CRT vs. LCD



<http://en.wikipedia.org/wiki/Lcd>

http://en.wikipedia.org/wiki/Cathode_ray_tube

Laser



<http://en.wikipedia.org/wiki/Laser>

LED

