SŁOŃCE

$R_{\odot} = 6.96 \cdot 10^{10}$ cm ~ 109 $R_{\oplus}$

$M_{\odot} = 1.99 \cdot 10^{33}$ g = 333000 $M_{\odot}$ = 99.866 % M.UK.Słońca

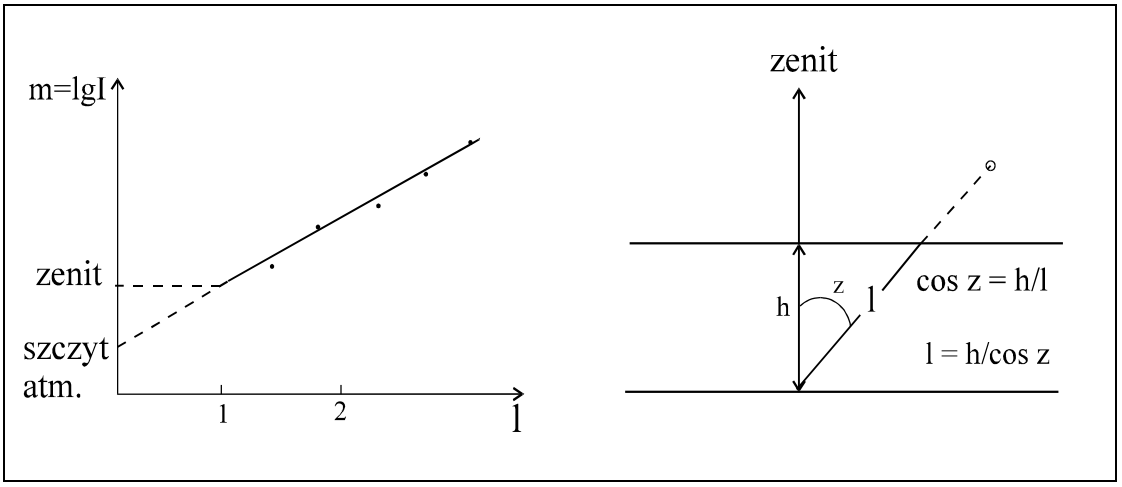
$\rho = 1.41$ g/cm^3 = 0.256 $\rho_{\oplus}$

$g = 2.74 \cdot 10^4$ cm/s^2 ~ 28 g

stała słoneczna = $1.4 \cdot 10^3$ W/m^2

METODY WYZNACZANIA

1)



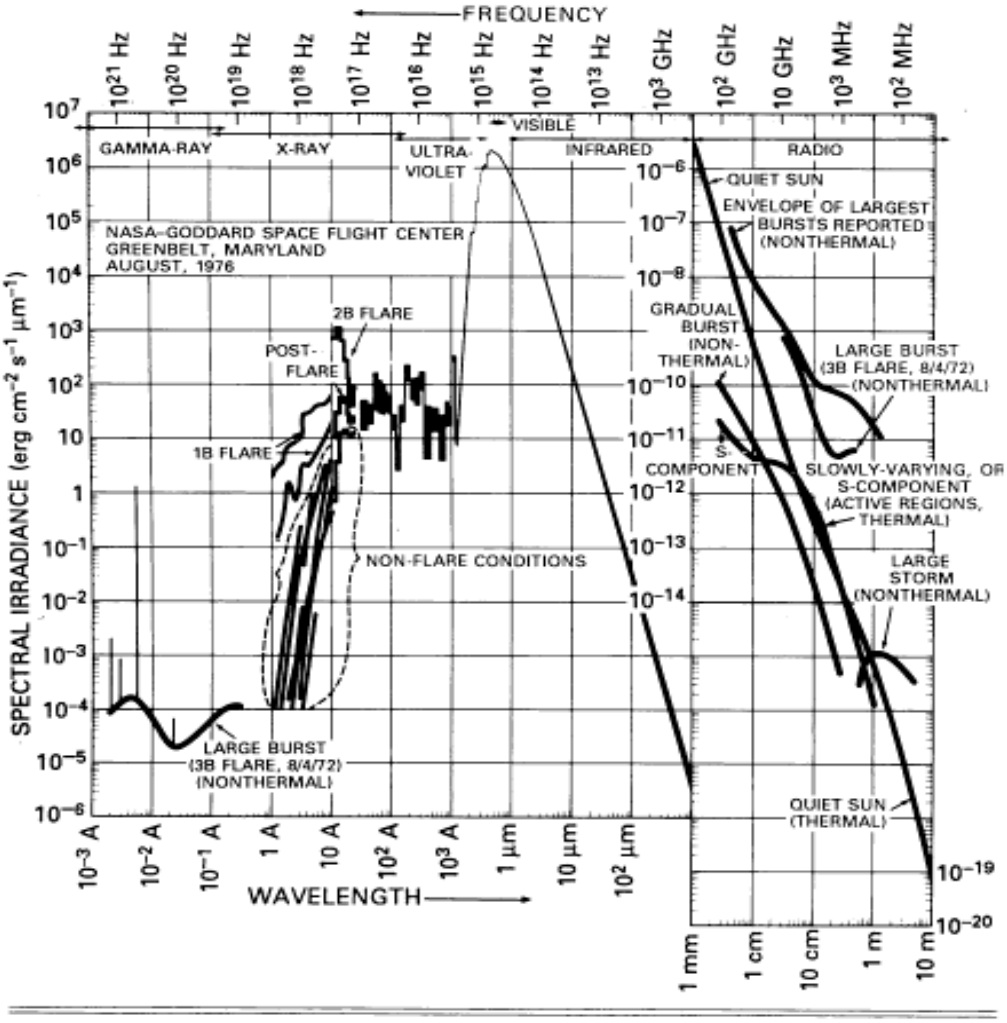
2) Sputniki

Luminancja

$L_{\odot} = 4\pi R^2 \cdot S$ gdzie R-odległość Ziemi od Słońca średnio równy 1 A.U.

$L_{\odot} = 3.86 \cdot 10^{33}$ erg/s = $3.86 \cdot 10^{26}$ W 1MW=10^6W

The solar spectral irradiance from radio waves to gamma-rays.
(Courtesy H. Malitson and the National Space Science Data Center.)



Promieniowanie Słońca

Temperatura fotosfery

1)Efektywna

$$E = \frac{L_{\odot}}{4p\mathrm{R}_{\odot}^{\ 2}} = s \cdot T_{ef.}^{\ 4} \qquad T_{ef.} = \sqrt[4]{\frac{L_{\odot}}{s\ 4p\mathrm{R}_{\odot}^{\ 2}}}$$

$$s = 5.67 \cdot 10^{-5} \frac{erg}{cm^2\ s \cdot 1^{o^4}} \qquad T_{ef.} = 5780^{o}\,K$$

2) T_{max} Prawo Viena $$l_{max} = \frac{0.290}{T_{max}}$$

$$T_{max} = \frac{0.290}{l_{max}} = 6750^{o}$$

3) T_j - jasnościowa T_j

λ = 1000 A$^{\circ}$	4500 $^{\circ}$K
λ = 2500 A$^{\circ}$	5000 $^{\circ}$K
λ = 5500 A$^{\circ}$	6400 $^{\circ}$K
λ = 1 M	1000000 $^{\circ}$K

1 A$^{\circ}$= 10^{-10}m

4) T_K - barwy T_K

λ_{λ}	4700 - 5400 A$^{\circ}$	6500
λ_{λ}	4300 - 4700 A$^{\circ}$	8000

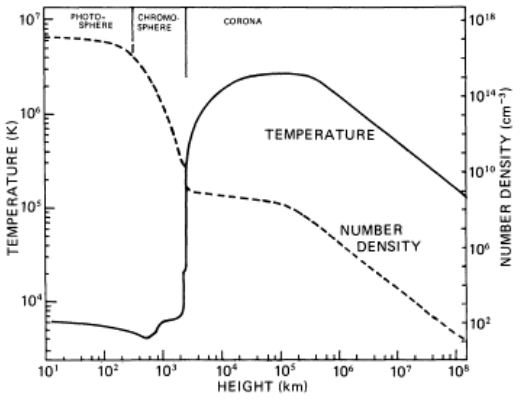
Wzór Plancka

$$e_n\,dn = \frac{2phn^3}{c^2}\,\frac{1}{e^{\frac{hn}{kT}}-1}\,dn$$

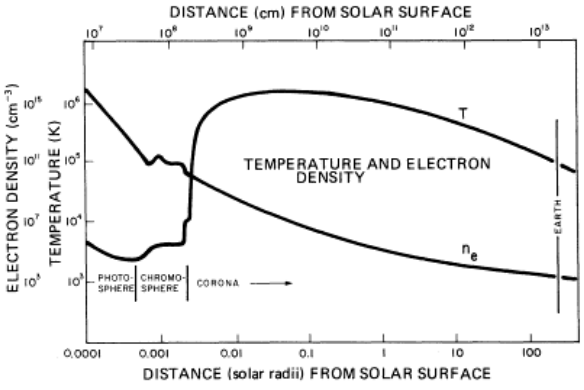
$$e_l\,dl = \frac{2phc^2}{l^5}\cdot\frac{1}{e^{\frac{hc}{lkT}}-1}\,dl$$

The Sun *(cont.)*

Temperature and density as a function of distance from the solar surface. (Courtesy of G. Withbroe, Harvard/Smithsonian Center for Astrophysics.)



Solar temperature and electron density. (Adapted from Carrigan, A. L. & Skrivanek, *Aerospace Environment*, Air Force Cambridge Research Laboratories, Massachusetts, 1974.)



Blackbody radiation (cgs units)

Planck functions (brightness of a blackbody)

$$B_\nu(T) = \frac{2h\nu^3}{c^2} \frac{1}{\left(\exp\left(\frac{h\nu}{kT}\right) - 1\right)} \quad \text{erg cm}^{-2}\,\text{s}^{-1}\,\text{Hz}^{-1}\,\text{sr}^{-1}$$

$$B_\lambda(T) = \frac{2hc^2}{\lambda^5} \frac{1}{\left(\exp\left(\frac{hc}{\lambda kT}\right) - 1\right)} \quad \text{erg cm}^{-2}\,\text{s}^{-1}\,\text{cm}^{-1}\,\text{sr}^{-1}$$

$$B_{\tilde\nu}(T) = \frac{2hc^2\tilde\nu^3}{\left(\exp\left(\frac{hc\tilde\nu}{kT}\right) - 1\right)} \quad \text{erg cm}^{-2}\,\text{s}^{-1}\,(\text{cm}^{-1})^{-1}\,\text{sr}^{-1}$$

$$B_\nu(T)\,d\nu = B_\lambda(T)\,d\lambda = B_{\tilde\nu}(T)\,d\tilde\nu$$

Rayleigh–Jeans law

$h\nu/kT << 1$

$$B_\nu(T) = 2\left(\frac{\nu}{c}\right)^2 kT$$

Wien's law

$h\nu/kT >> 1$

$$B_\nu(T) = \frac{2h\nu^3}{c^2} \exp\left(-\frac{h\nu}{kT}\right)$$

Stefan–Boltzmann law

$$\text{total emittance} = \pi \int_0^\infty B_\nu(T)\,d\nu = \sigma T^4 \quad \text{erg cm}^{-2}\,\text{s}^{-1}$$

$$\text{where } \sigma = \frac{2\pi^5 k^4}{15c^2h^3} = 5.67 \times 10^{-5} \quad \text{erg cm}^{-2}\,\text{deg}^{-4}\,\text{s}^{-1}$$

Wien displacement law

Maximizing B_ν:

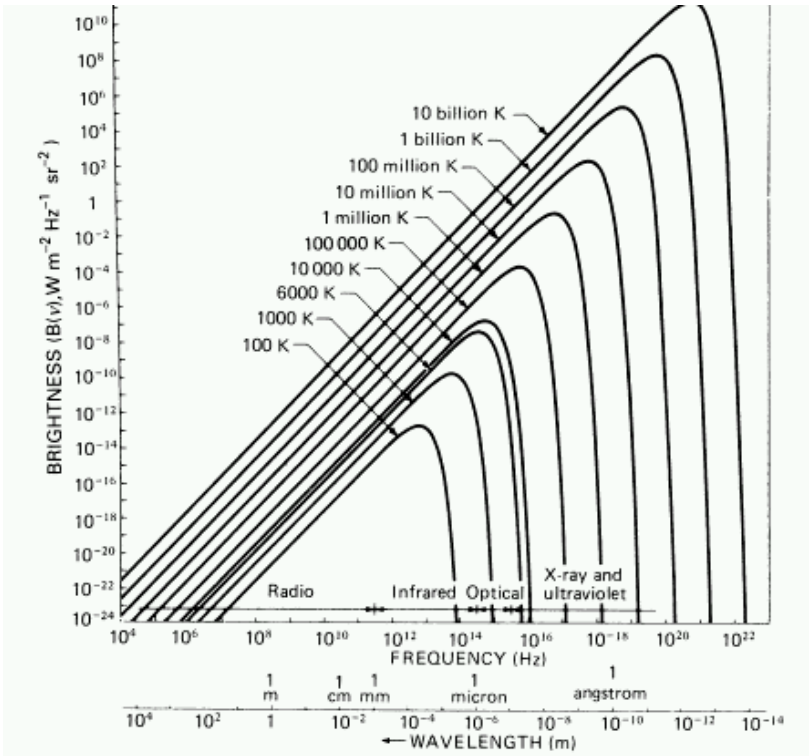
$\nu_m = 5.9 \times 10^{10} T$ Hz

$\lambda_m = 0.51 T^{-1}$ cm

Maximizing B_λ:

$\nu_m = 10.3 \times 10^{10} T$ Hz

$\lambda_m = 0.29 T^{-1}$ cm



Mean photon energy

$$\langle h\nu \rangle = \frac{\int_0^\infty B_\nu(T)\,\mathrm{d}\nu}{\int_0^\infty (B_\nu(T)/h\nu)\,\mathrm{d}\nu} = \left(\frac{\zeta(4)}{\zeta(3)}\right)\left(\frac{\Gamma(4)}{\Gamma(3)}\right)kT = 2.7012kT.$$

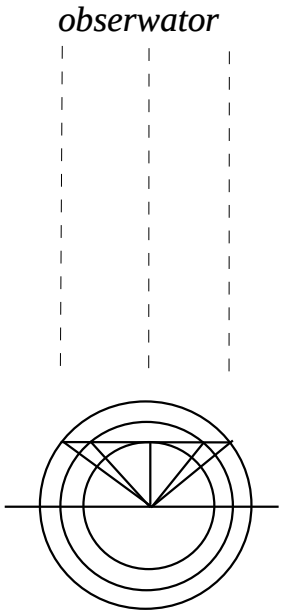
where $\zeta(n)$ = Riemann zeta function; $\Gamma(n)$ = gamma function.

BUDOWA SŁOŃCA SPOKOJNEGO

JĄDRO - budowa omówiona będzie później

FOTOSFERA

skład chemiczny: H=72.7%, H_2=26.2%, O=0.69%, C=0.31%, N=0.06%



$r = 2 \cdot 10^{-7} \frac{g}{cm^3}$

$T = 6000\,^{\circ}K$

$p = 0.1\,at$

$n = 10^{7} \frac{1}{cm^3}$

$r = 7 \cdot 10^{10}\ cm$

CHROMOSFERA

$r = 3 \cdot 10^{-12} \frac{g}{cm^3}$

$T = 10000\,^{\circ}K$

$p = 10^{-6}\ at$

$n = 10^{12}\ cm^{-3}$

KORONA

$r = 10^{-15} \frac{g}{cm^3}$

$T = 1.5 \cdot 10^{6}\ K$

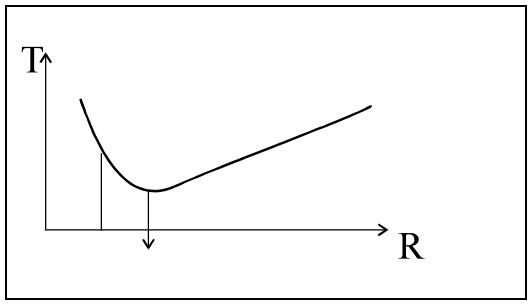
$p = 6 \cdot 10^{-8}\ at$

$n = 3 \cdot 10^{8}\ cm^{-3}$

WIATR SŁONECZNY - promieniowanie kosmiczne

Temperatura w funkcji odległości od słońca

Poczernienienie brzegowe



SŁOŃCE NIESTACJONARNE

ROTACJA SŁOŃCA

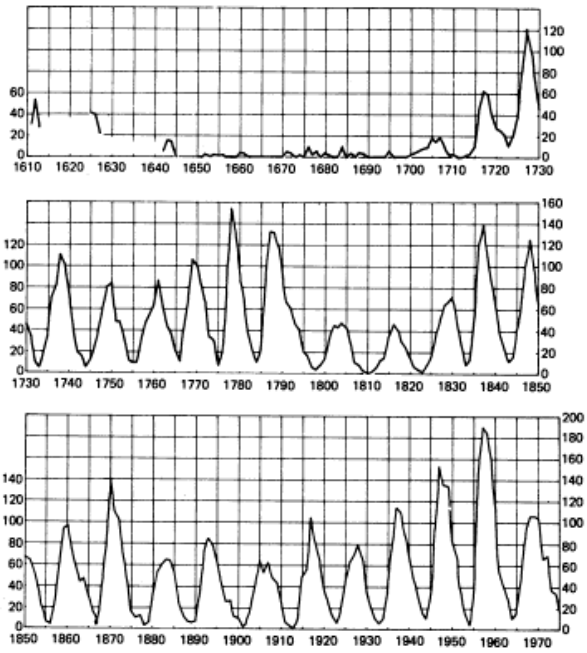
T = 25 dni równik

T = 30 dni bieguny

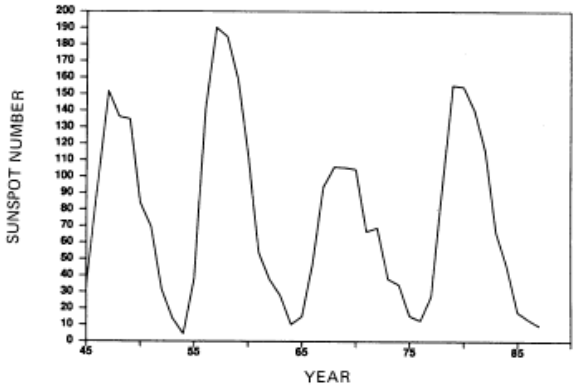
Niestacjonarne procesy na słońcu.

The Sun *(cont.)*

Annual mean sunspot number, AD 1610–1975. (From Eddy, J. in *The Solar Output and its Variation*, O. White, ed., Colorado Association University Press, 1977.)



Yearly mean sunspot numbers 1945–87. (US Department of Commerce.)



Fotosfera

-granulacja

R_g = 700 km,

τ = 5 - 15 minut

- plaże

- plamy

Liczba Volfa

R = K (10 g + s)

czas istnienia 30-60 minut do kilku dni

R=35000km

11 letni cykl

Wykres motylka

Chromosfera

- szpikule

R = 1000 km

- pretuberancje

- bryzgi chromosferyczne