

# Kompjuterski softver i simulacije u astronomiji

# Pege i rotacija Sunca

# Važne formule

$$P = \frac{365.25 * S}{S + 365.25}$$

$P$  – siderički period

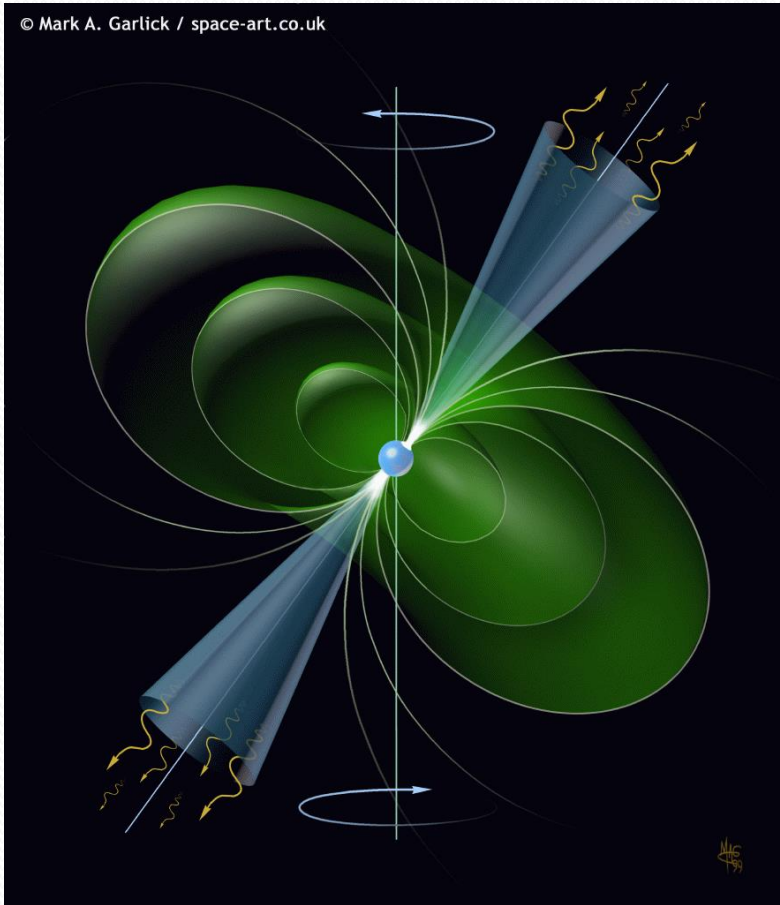
$S$  – sinodički period

$$S_{dani} = \frac{360^{\circ}}{nagib_{(stepen/danu)}}$$

# Radio astronomija pulsara

# Pulsari

© Mark A. Garlick / space-art.co.uk



# Radio teleskop



# Određivanje rastojanja

- “disperzija” – različita brzina radio talasa u zavisnosti od sredine:
  - Međuzvezdani prostor nije vakuum, nekoliko atoma/elektrona u  $\text{cm}^3$
  - Niža frekvenca – sporiji talasi
  - Viša frekvenca – brži talasi

# “Obična” fizika

- Dva trkača
- **A**: 5 km/h, **B**: 10 km/h
- Rastojanje nije poznato, ali znamo da su krenuli istovremeno

$$T_A = \frac{L}{V_A}, T_B = \frac{L}{V_B}$$

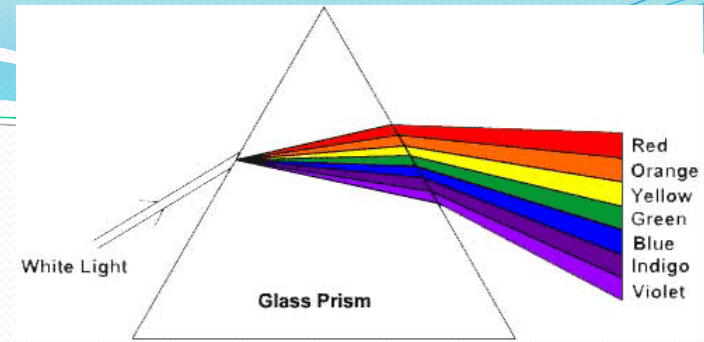
$$T_B - T_A = \frac{L}{V_B} - \frac{L}{V_A}$$

$$L = \frac{T_B - T_A}{\left( \frac{1}{V_B} - \frac{1}{V_A} \right)}$$





# Rastojanje pulsara



- Brzina talasa:

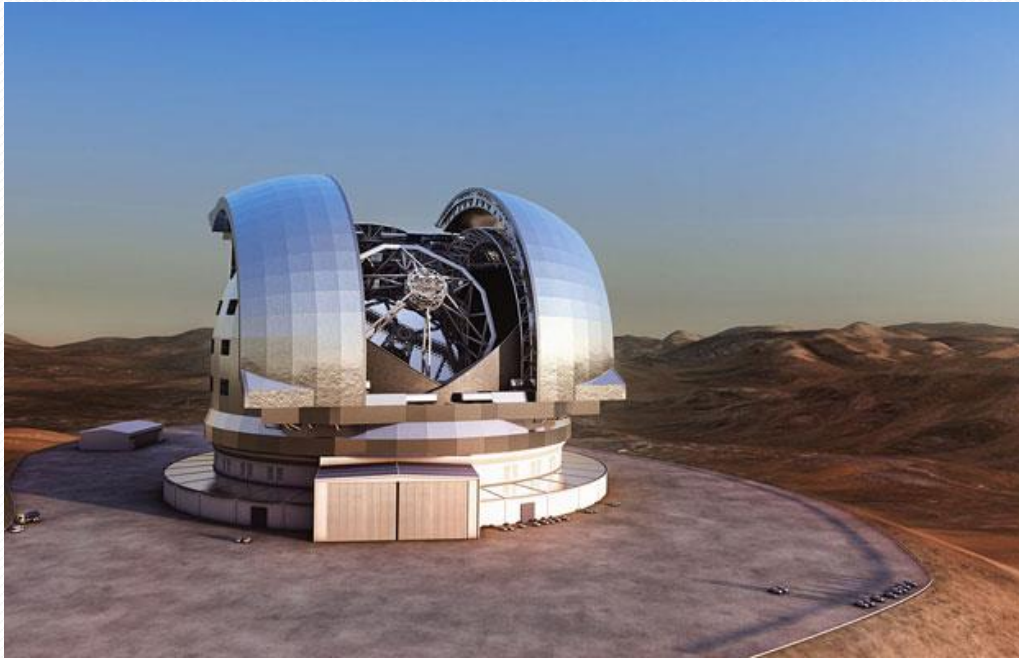
$$v = \frac{f^2}{4150 \cdot n_e} = \frac{f^2}{124.5}$$

- $n_e$  – gustina međuzvezdanog prostora,  $0.03 \text{ el./cm}^3$
- Rastojanje:

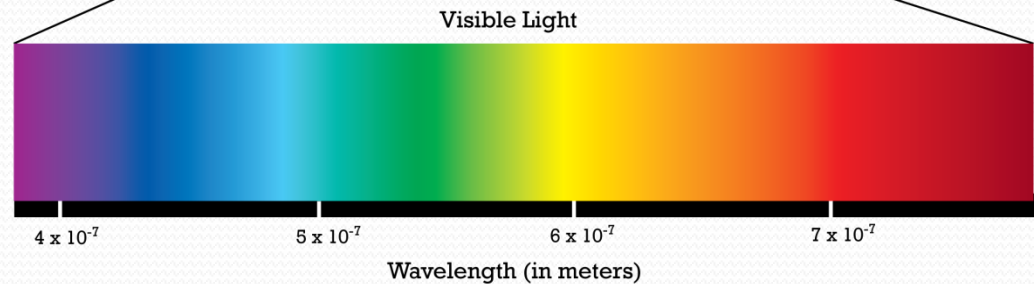
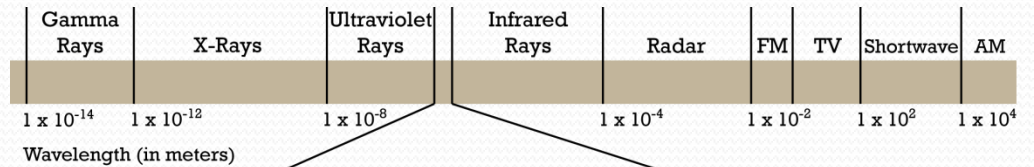
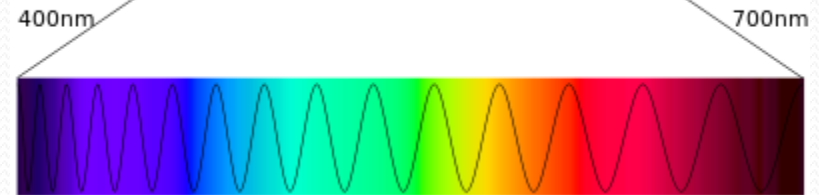
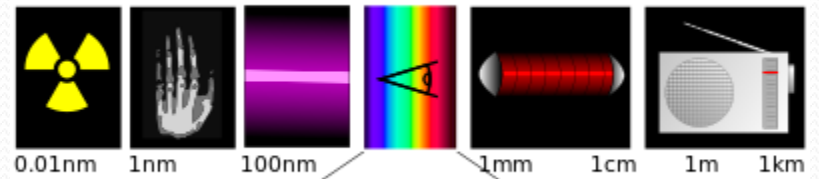
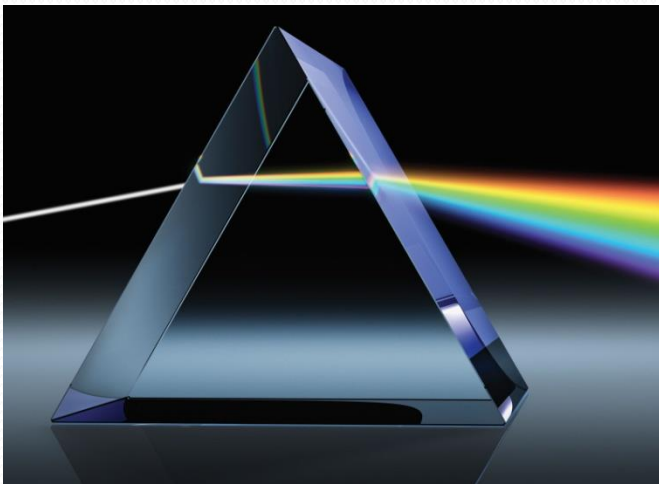
$$D = \frac{T_2 - T_1}{124.5 \cdot \left( \left( \frac{1}{f_2} \right)^2 - \left( \frac{1}{f_1} \right)^2 \right)}$$

# Klasifikacija zvezda

# Teleskop

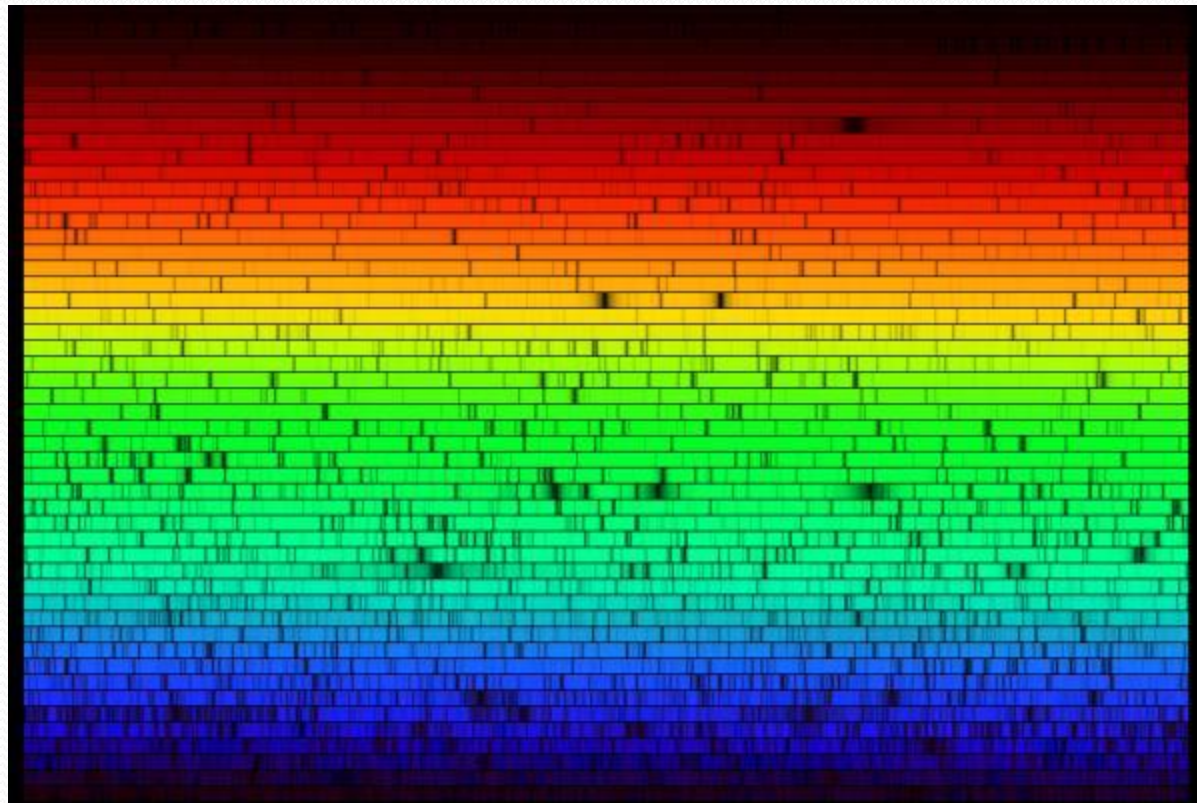


# Spektar

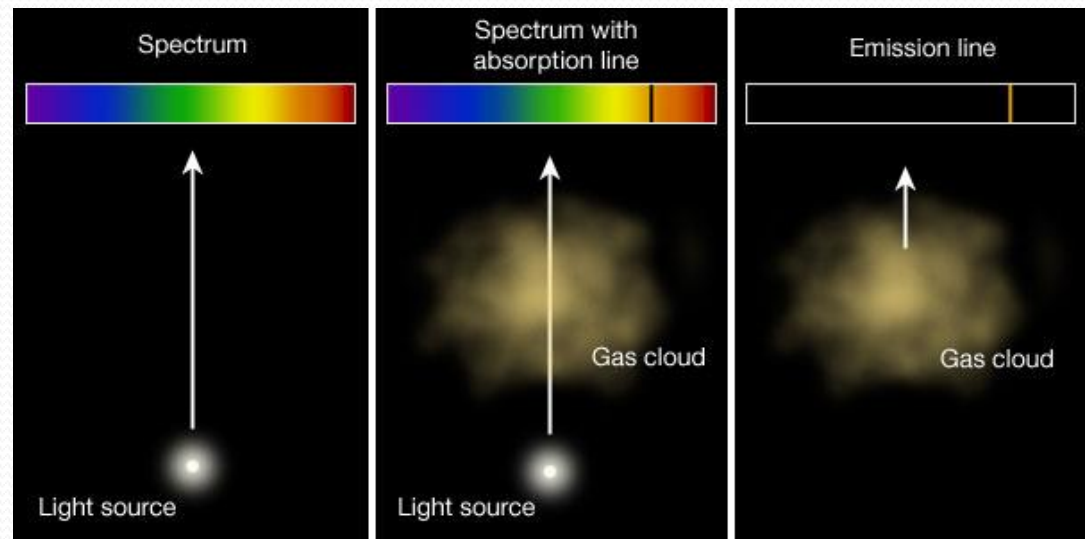
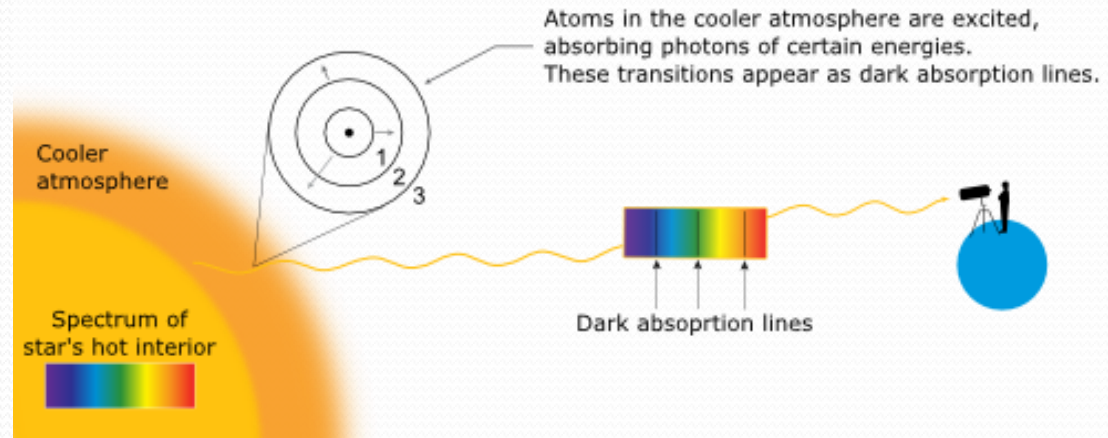
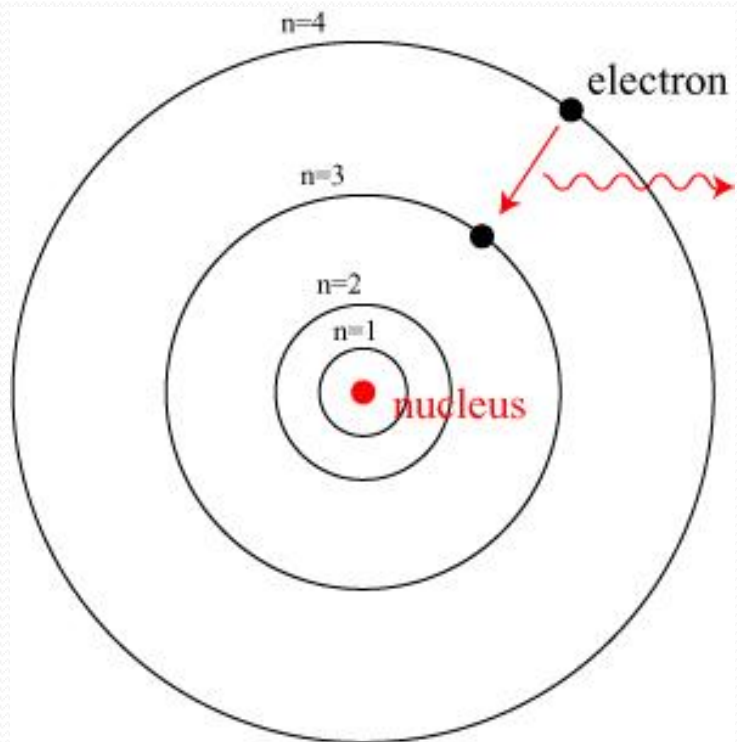


# Spektri zvezda

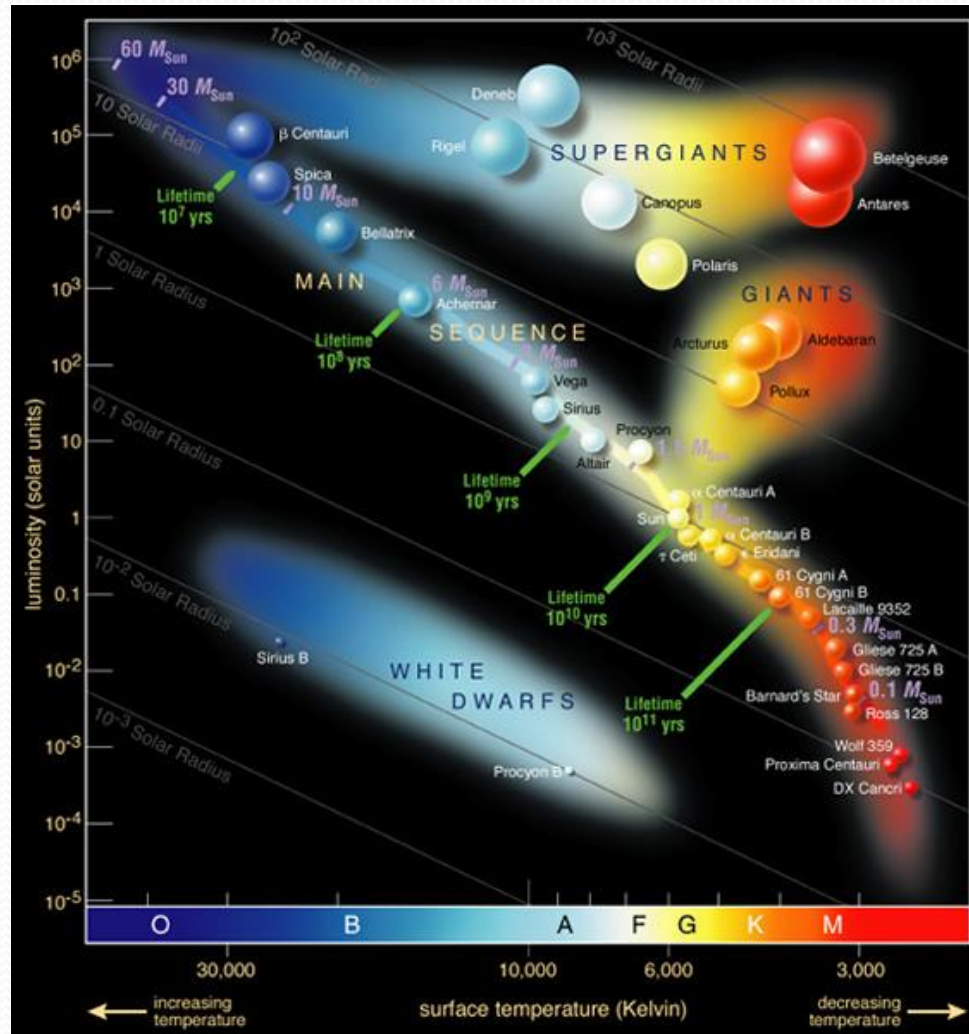
- 1870. godina, Joseph von Fraunhofer



# Kako nastaju?



# Hertzsprung–Russell diagram



# Zvezde

- **Sirius**

- Ra. 06h 45m 08, Dec.  $-16^{\circ} 42' 58$
- Klasa: A1V; rastojanje:  $\sim 2.5\text{pc}$ ; temp:  $\sim 10000\text{K}$
- <http://en.wikipedia.org/wiki/Sirius>

- **Betelgeuse**

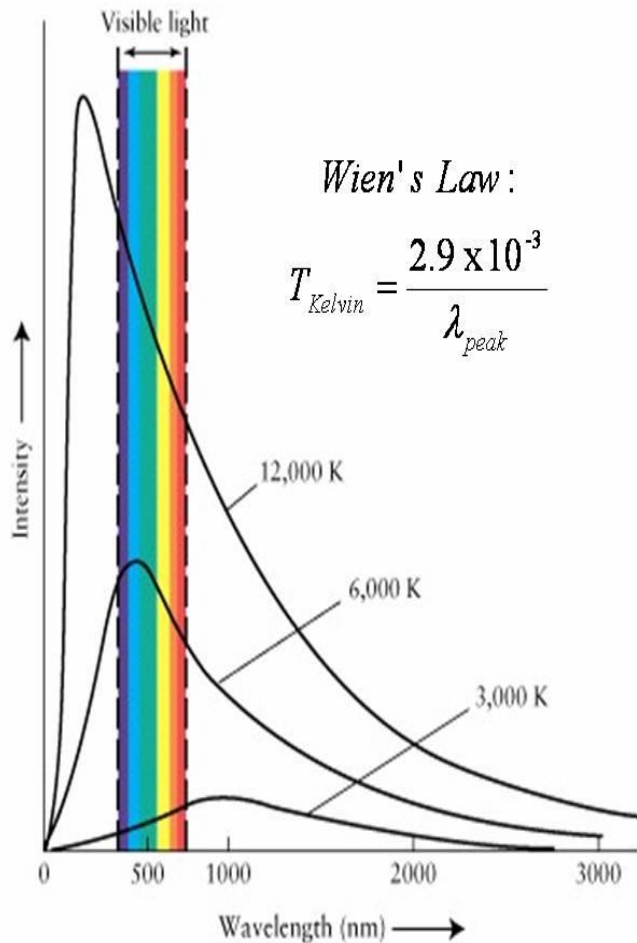
- Ra. 05h 55m 10, Dec.  $+07^{\circ} 24' 25$
- Klasa: M2I; rastojanje:  $\sim 200\text{pc}$ ; temp:  $\sim 3400\text{K}$ ;
- <http://en.wikipedia.org/wiki/Betelgeuse>

- **Algol**

- Ra. 03h 08m 10, Dec.  $+40^{\circ} 57' 20$
- Klasa: B8V, rastojanje:  $\sim 30\text{pc}$ , temp:  $\sim 9000\text{K}$
- <http://en.wikipedia.org/wiki/Algol>



# Vinov zakon



Classification	Temperature	Max Wavelength	Color
<b>O0</b>	40,000 K	72.5 nm	Blue
<b>B0</b>	20,000 K	145 nm	Light Blue
<b>A0</b>	10,000 K	290 nm	White
<b>F0</b>	7,500 K	387 nm	Yellow-White
<b>G0</b>	5,500 K	527 nm	Yellow
<b>K0</b>	4,000 K	725 nm	Orange
<b>M0</b>	3,000 K	966 nm	Red

Određivanje temperature zvezde

### Main sequence stars (V)

Spectral Type	Temperature (K)	Absolute Magnitude	Luminosity (in solar luminosities)
O5	54,000	-4.5	200,000
O6	45,000	-4.0	140,000
O7	43,300	-3.9	120,000
O8	40,600	-3.8	80,000
O9	37,800	-3.6	55,000
B0	29,200	-3.3	24,000
B1	23,000	-2.3	5550
B2	21,000	-1.9	3190
B3	17,600	-1.1	1060
B5	15,200	-0.4	380
B6	14,300	0	240
B7	13,500	0.3	140
B8	12,300	0.7	73
B9	11,400	1.1	42
A0	9600	1.5	24
A1	9330	1.7	20
A2	9040	1.8	17
A3	8750	2.0	14
A4	8480	2.1	12
A5	8310	2.2	11
A7	7920	2.4	8.8
F0	7350	3.0	5.1
F2	7050	3.3	3.8
F3	6850	3.5	3.2
F5	6700	3.7	2.7
F6	6550	4.0	2.0
F7	6400	4.3	1.5
F8	6300	4.4	1.4
G0	6050	4.7	1.2
G1	5930	4.9	1.1
G2	5800	5.0	1
G5	5660	5.2	0.73
G8	5440	2.6	0.51

$$\log D = \frac{m - M + 5}{5}$$

$$D = 10^{\log D}$$

K0	5240	6.0	0.38
K1	5110	6.2	0.32
K2	4960	6.4	0.29
K3	4800	6.7	0.24
K4	4600	7.1	0.18
K5	4400	7.4	0.15
K7	4000	8.1	0.11
M0	3750	8.7	0.080
M1	3700	9.4	0.055
M2	3600	10.1	0.035
M3	3500	10.7	0.027
M4	3400	11.2	0.022
M5	3200	12.3	0.011
M6	3100	13.4	0.0051
M7	2900	13.9	0.0032
M8	2700	14.4	0.0020
L0	2600	*	0.00029
L3	2200	*	0.00013
L8	1500	*	0.000032
T2	1400	*	0.000025
T6	1000	*	0.0000056
T8	800	*	0.0000036

\* - not visible to the human eye (for the most part)

### Giants (III)

Spectral Type	Temperature (K)	Absolute Magnitude	Luminosity (in solar luminosities)
G5	5010	0.7	127
G8	4870	0.6	113
K0	4720	0.5	96
K1	4580	0.4	82
K2	4460	0.2	70
K3	4210	0.1	58
K4	4010	0.0	45
K5	3780	-0.2	32
M0	3660	-0.4	15
M1	3600	-0.5	13
M2	3500	-0.6	11
M3	3300	-0.7	9.5
M4	3100	-0.75	7.4
M5	2950	-0.8	5.1
M6	2800	-0.9	3.3

$$\log D = \frac{m - M + 5}{5}$$

$$D = 10^{\log D}$$

### Supergiants (I)

Spectral Type	Temperature (K)	Absolute Magnitude	Luminosity (in solar luminosities)
B0	21,000	-6.4	320,000
B1	16,000	-6.4	280,000
B2	14,000	-6.4	220,000
B3	12,800	-6.3	180,000
B5	11,500	-6.3	140,000
B6	11,000	-6.3	98,000
B7	10,500	-6.3	82,000
B8	10,000	-6.2	73,000
B9	9700	-6.2	61,000
A0	9400	-6.2	50,600
A1	9100	-6.2	44,000
A2	8900	-6.2	40,000
A5	8300	-6.1	36,000
F0	7500	-6	20,000
F2	7200	-6	18,000
F5	6800	-5.9	16,000
F8	6150	-5.9	12,000
G0	5800	-5.9	9600
G2	5500	-5.8	9500
G5	5100	-5.8	9800
G8	5050	-5.7	11,000
K0	4900	-5.7	12,000
K1	4700	-5.6	13,500
K2	4500	-5.6	15,200
K3	4300	-5.6	17,000
K4	4100	-5.5	18,300
K5	3750	-5.5	20,000
M0	3660	-5.3	50,600
M1	3600	-5.3	52,000
M2	3500	-5.3	53,000
M3	3300	-5.3	54,000
M4	3100	-5.2	56,000
M5	2950	-5.2	58,000

# Merenje Hablove const.

# Potrebne formule

$$M = m + 5 - 5 * \log D$$

$$\log D = \frac{m - M + 5}{5}$$

$$v_K = c * \frac{\Delta\lambda_K}{\lambda_K}$$

$$v_H = c * \frac{\Delta\lambda_H}{\lambda_H}$$

$$\Delta\lambda_K = \lambda_{K_{izmereno}} - \lambda_K$$

$$\Delta\lambda_H = \lambda_{H_{izmereno}} - \lambda_H$$

$$H = \frac{v}{D}$$

Starost svemira:

$$D = R * T \longrightarrow T = \frac{D}{R}$$