Apparent magnitude	Brightness relative to magnitude 0	Example
−27	6.31×10^{10}	Sun
−26	2.51×10^{10}	
−25	1×10^{10}	
−24	3.98×10^{9}	
−23	1.58×10^{9}	
−22	6.31×10^{8}	
−21	2.51×10^{8}	
−20	1×10^{8}	
−19	3.98×10^{7}	
−18	1.58×10^{7}	
−17	6.31×10^{6}	
−16	2.51×10^{6}	
−15	1×10^{6}	
−14	3.98×10^{5}	
−13	1.58×10^{5}	Full moon
−12	6.31×10^{4}	
−11	2.51×10^{4}	
−10	1×10^{4}	
−9	3.98×10^{3}	Iridium flare
−8	1.58×10^{3}	

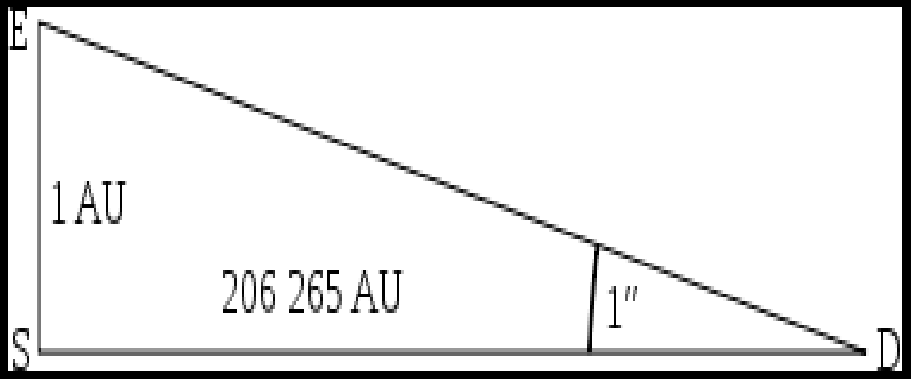
Apparent magnitude	Brightness relative to magnitude 0	Example
−7	631	SN 1006 supernova
−6	251	ISS (max)
−5	100	Venus (max)
−4	39.8	
−3	15.8	Jupiter (max), Mars (max)
−2	6.31	Mercury (max)
−1	2.51	Sirius
0	1	Vega, Saturn (max)
1	0.398	Antares
2	0.158	Polaris
3	0.0631	Cor Caroli
4	0.0251	Acubens
5	0.01	Vesta (max), Uranus (max)
6	3.98×10^{-3}	**typical limit of naked eye**[note 2]
7	1.58×10^{-3}	Ceres (max)
8	6.31×10^{-4}	Neptune (max)
9	2.51×10^{-4}	
10	1×10^{-4}	typical limit of 7x50 binoculars
11	3.98×10^{-5}	
12	1.58×10^{-5}	

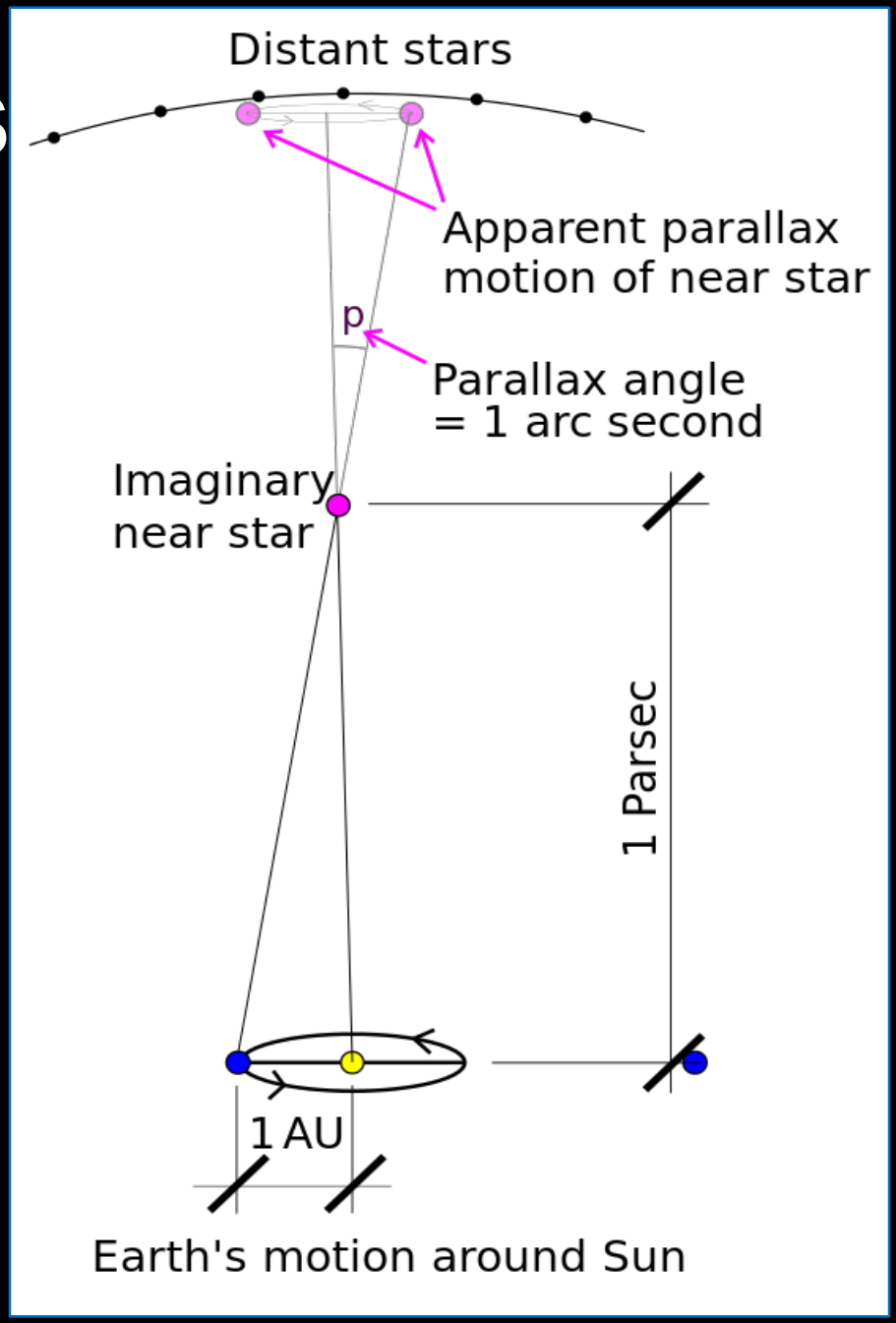
Apparent magnitude	Brightness relative to magnitude 0	**Pogson's ratio:** $\sqrt[5]{100} \approx 2.512$ Example
13	6.31×10^{-6}	3C 273 quasar / limit of 4.5–6" (11–15 cm) telescopes
14	2.51×10^{-6}	Pluto (max) / limit of 8–10" (20–25 cm) telescopes
15	1×10^{-6}	
16	3.98×10^{-7}	Charon (max)
17	1.58×10^{-7}	
18	6.31×10^{-8}	
19	2.51×10^{-8}	
20	1×10^{-8}	
21	3.98×10^{-9}	Callirrhoe (satellite of Jupiter)
22	1.58×10^{-9}	
23	6.31×10^{-10}	
24	2.51×10^{-10}	
25	1×10^{-10}	Fenrir (satellite of Saturn)
26	3.98×10^{-11}	
27	1.58×10^{-11}	visible light limit of 8m telescopes
28	6.31×10^{-12}	
29	2.51×10^{-12}	
30	1×10^{-12}	
31	3.98×10^{-13}	
32	1.58×10^{-13}	visible light limit of HST

Distance Modulus

$$m - M = 5\left[\log_{10}(d) - 1\right]$$

- Absolute magnitude (*M*)
  - Apparent magnitude of an object at a standard luminosity distance of exactly 10.0 parsecs (~32.6 ly) from the observer on Earth
  - Allows true luminosity of astronomical objects to be compared without regard to their distances
- Unit: parsec (pc)
  - Distance at which 1 AU subtends an angle of 1″
  - 1 AU = 149 597 870 700 m (≈1.50 x 10^8 km)
  - 1 pc ≈ 3.26 ly
  - 1 pc ≈ 206 265 AU





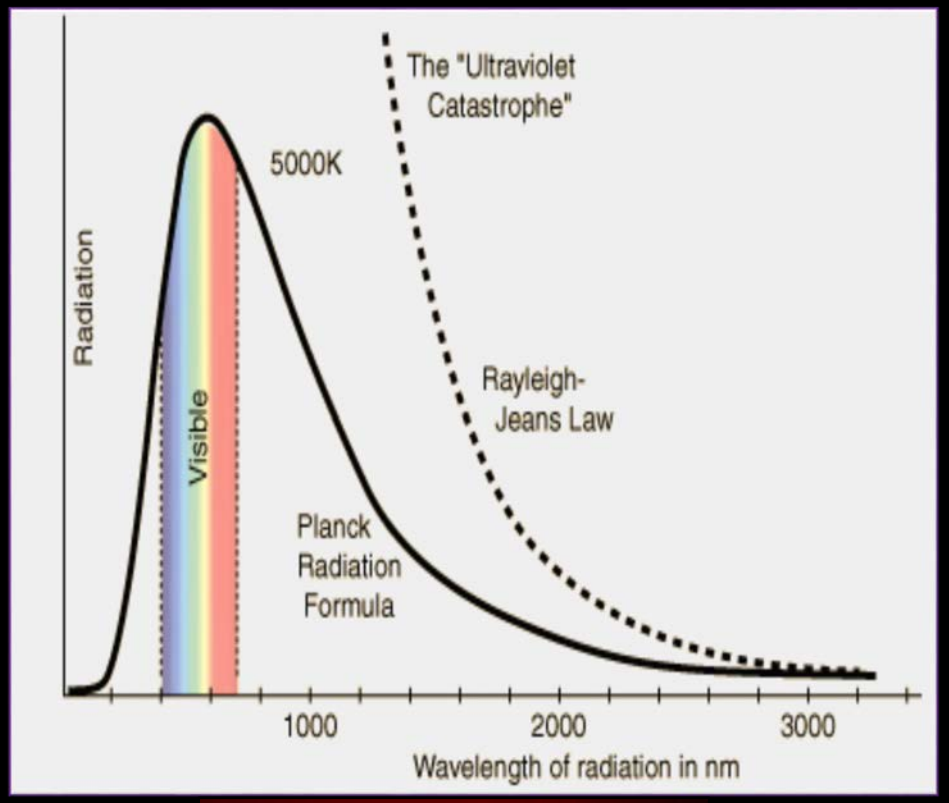
Stellar Astrophysics

- Stefan-Boltzmann Law:

$$F_{bol} = \sigma T^4; \sigma = \frac{2\pi^5 k^4}{15c^2h^3} = 5.67x10^{-5} ergs^{-1}cm^{-2}K^{-4}$$

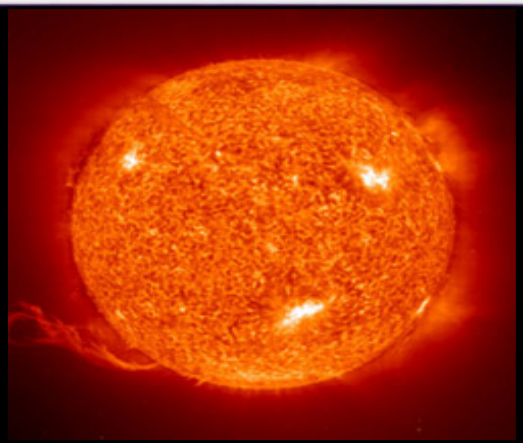
  - Effective temperature of a star: Temp. of a black body with the same luminosity per surface area
  - Stars can be treated as black body radiators to a good approximation
  - Effective surface temperature can be obtained from the B-V color index with the Ballesteros equation:

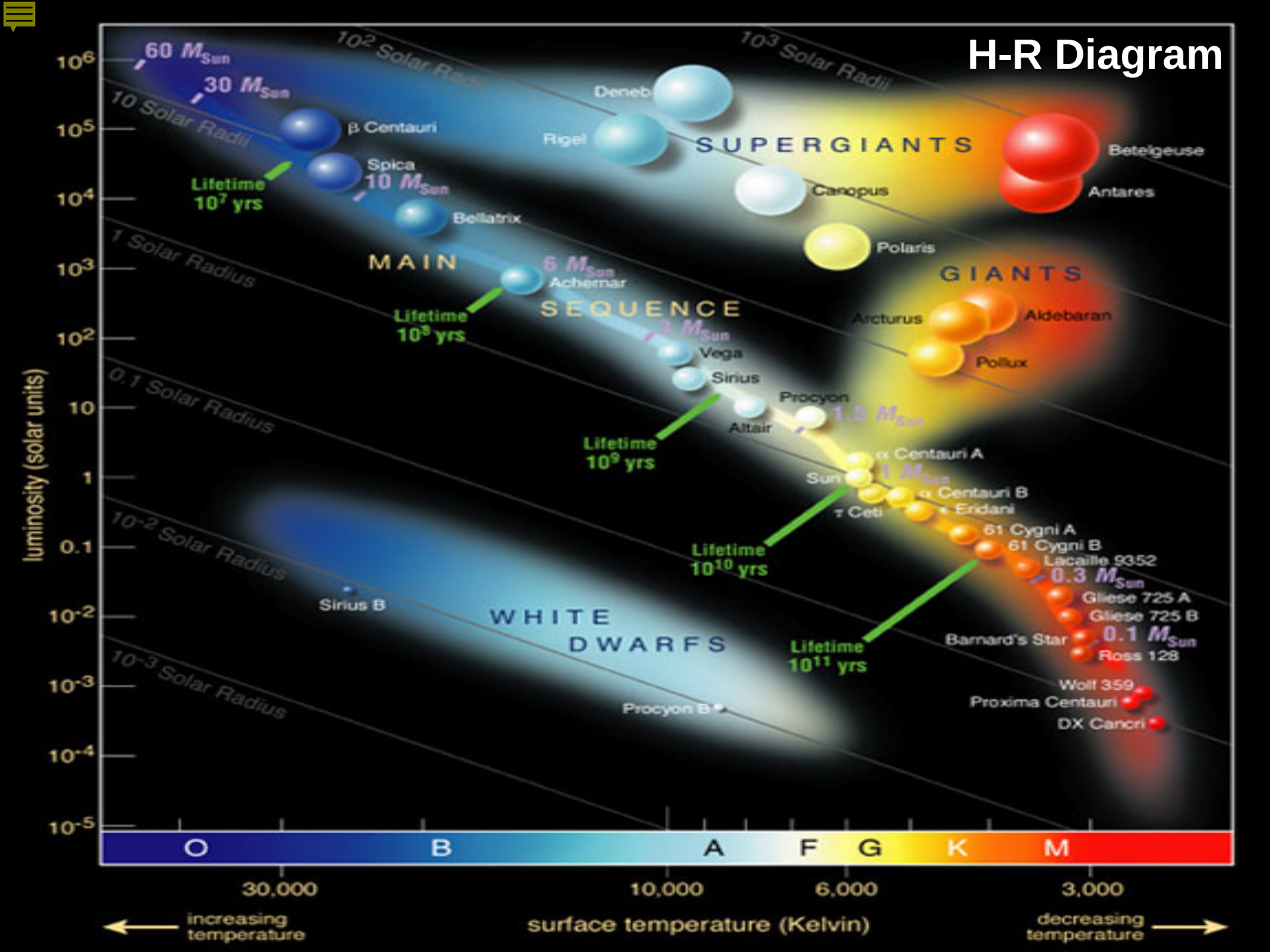
$$T = 4600\left(\frac{1}{0.92(B-V)+1.70} + \frac{1}{0.92(B-V)+0.62}\right)$$

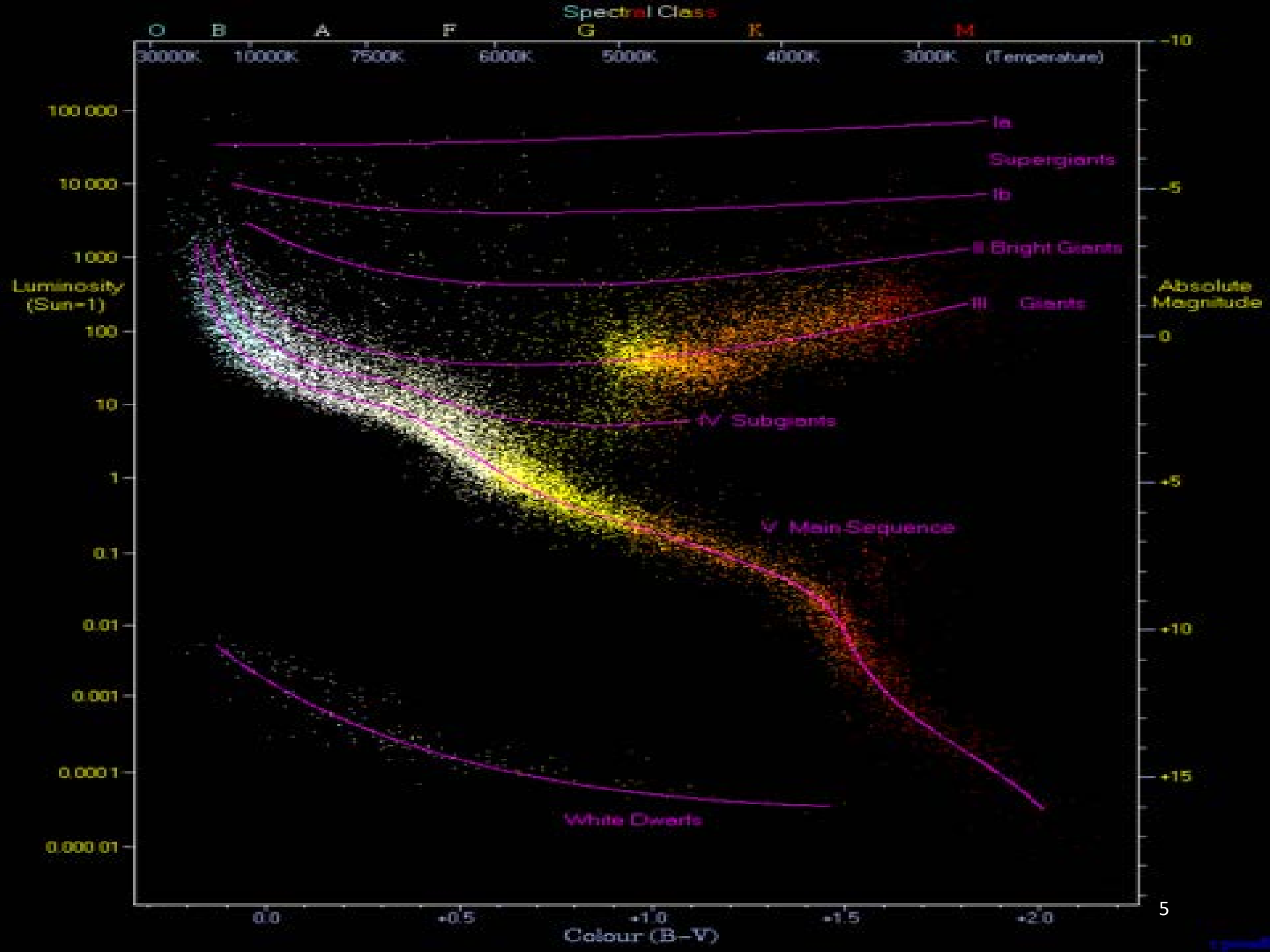


- **Luminosity**:

$$L = 4\pi r_*^2 \sigma T_E^4$$




H-R Diagram
luminosity (solar units)
10^6
10^5
10^4
10^3
10^2
10
1
0.1
10^{-2}
10^{-3}
10^{-4}
10^{-5}
60 M_{Sun}
30 M_{Sun}
10^2 Solar Radii
10^3 Solar Radii
10 Solar Radii
1 Solar Radius
0.1 Solar Radius
10^{-2} Solar Radius
10^{-3} Solar Radius
β Centauri
Spica
10 M_{Sun}
Lifetime 10^7 yrs
Bellatrix
MAIN
SEQUENCE
6 M_{Sun}
Achernar
Lifetime 10^8 yrs
3 M_{Sun}
Vega
Sirius
Lifetime 10^9 yrs
Procyon
Altair
1.5 M_{Sun}
α Centauri A
Sun
1 M_{Sun}
α Centauri B
ε Eridani
τ Ceti
Lifetime 10^{10} yrs
61 Cygni A
61 Cygni B
Lacaille 9352
0.3 M_{Sun}
Gliese 725 A
Gliese 725 B
Barnard's Star
0.1 M_{Sun}
Ross 128
Lifetime 10^{11} yrs
Wolf 359
Proxima Centauri
DX Cancri
Sirius B
WHITE
DWARFS
Procyon B
Deneb
Rigel
SUPERGIANTS
Canopus
Betelgeuse
Antares
Polaris
GIANTS
Arcturus
Aldebaran
Pollux
O
B
A
F
G
K
M
30,000
10,000
6,000
3,000
increasing temperature
surface temperature (Kelvin)
decreasing temperature


Spectral Class
O
B
A
F
G
K
M
30000K
10000K
7500K
6000K
5000K
4000K
3000K
(Temperature)
100 000
10 000
1000
100
10
1
0.1
0.01
0.001
0.000 1
0.000 01
Luminosity
(Sun=1)
-10
-5
0
+5
+10
+15
Absolute
Magnitude
Ia
Supergiants
Ib
II Bright Giants
III Giants
IV Subgiants
V Main-Sequence
White Dwarfs
0.0
+0.5
+1.0
+1.5
+2.0
Colour (B–V)