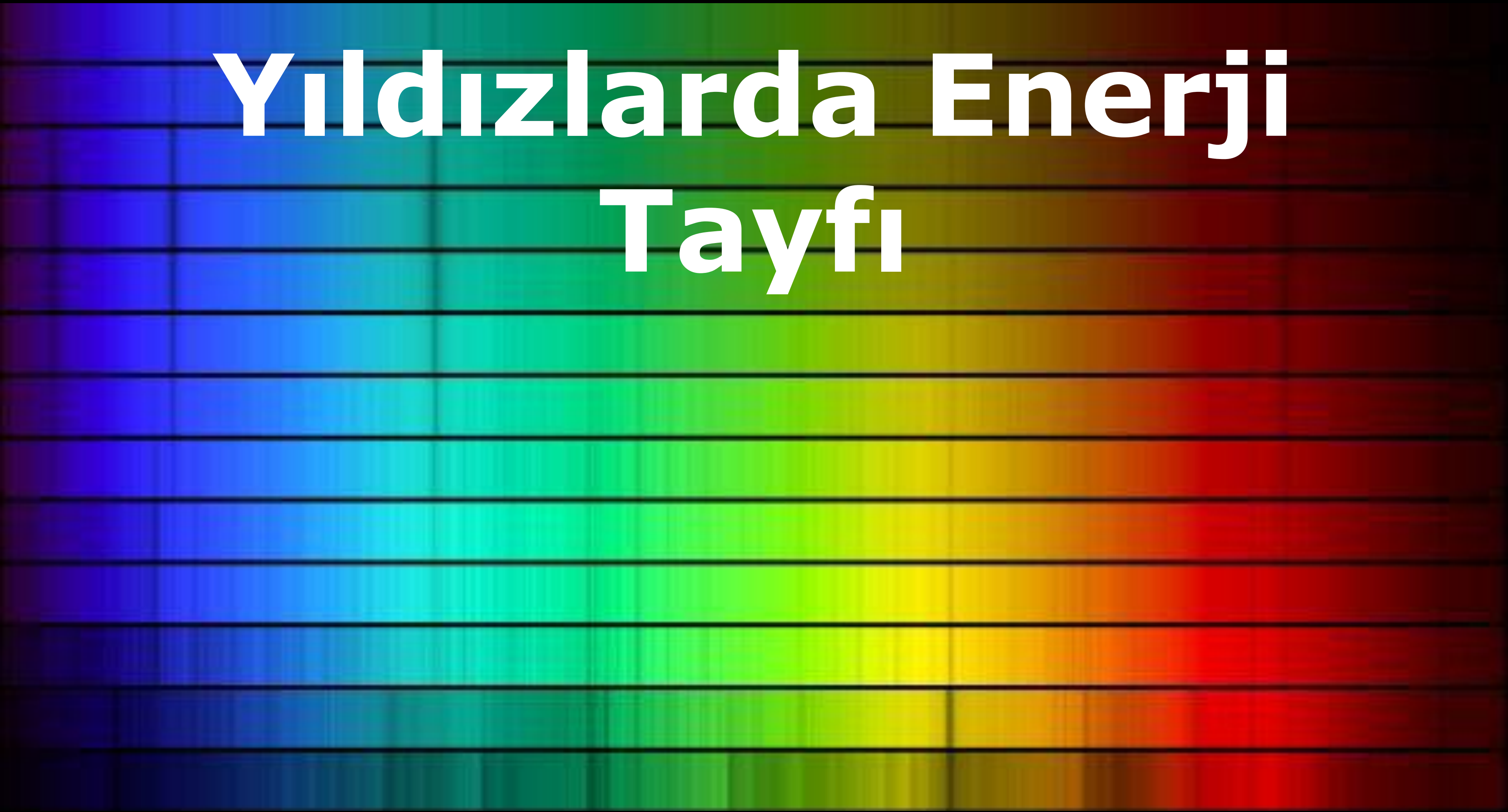
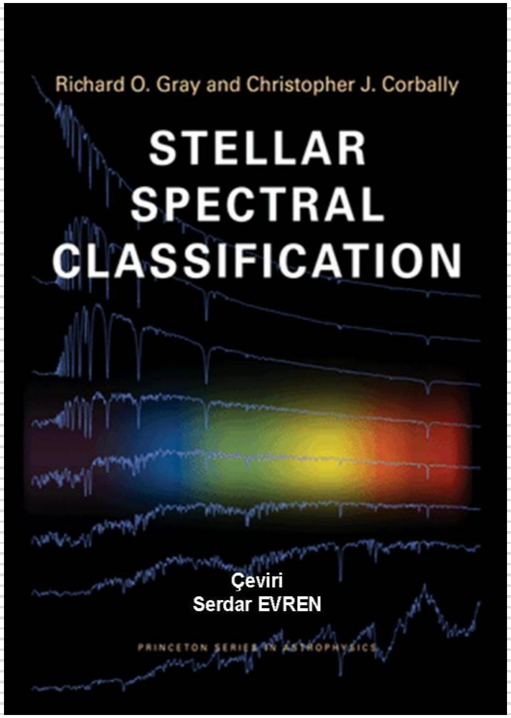
Yıldızlarda Enerji Tayfı

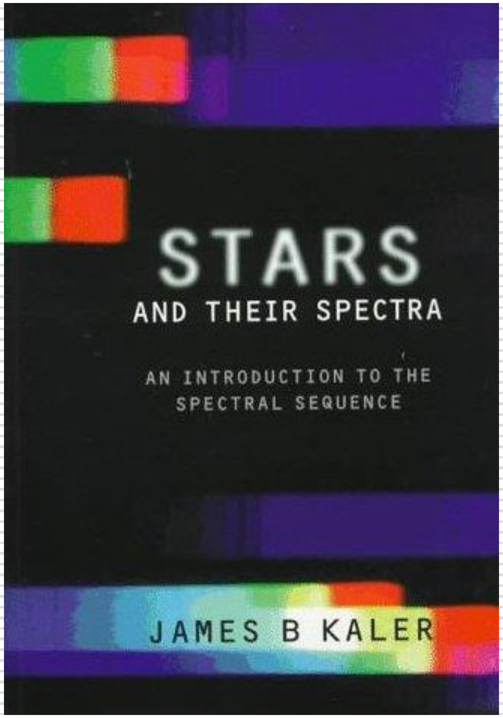


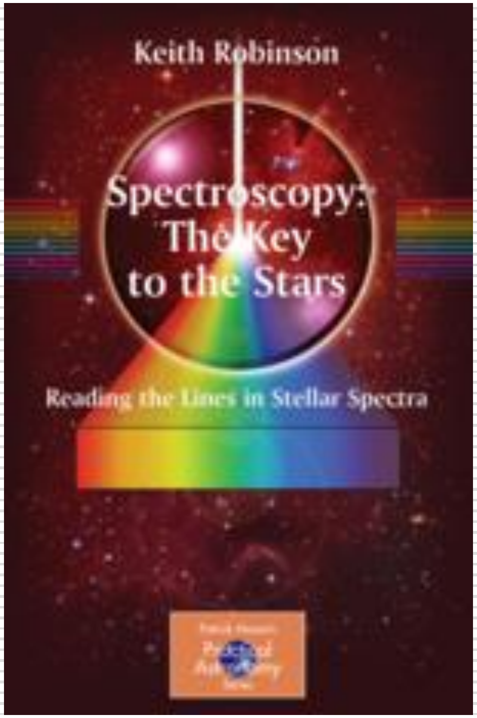
Serdar EVREN

2017

Kaynaklar


Richard O. Gray and Christopher J. Corbally
STELLAR SPECTRAL CLASSIFICATION
Çeviri
Serdar EVREN
PRINCETON SERIES IN ASTROPHYSICS


STARS
AND THEIR SPECTRA
AN INTRODUCTION TO THE SPECTRAL SEQUENCE
JAMES B KALER


Keith Robinson
Spectroscopy: The Key to the Stars
Reading the Lines in Stellar Spectra

İçerik

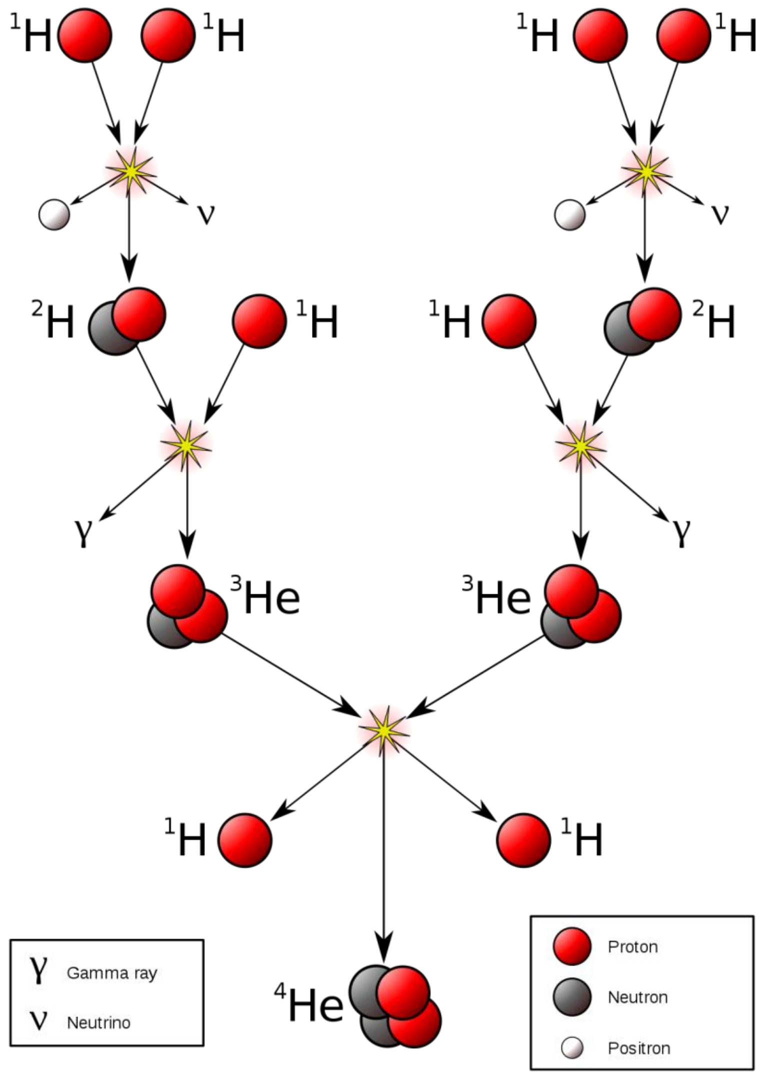
- Yıldızlar (Genel Bilgi)
- Atomlar ve tayflar
- Tayfsal sınıflama
- M Yıldızları
- K Yıldızları
- G Yıldızları
- F Yıldızları
- A Yıldızları
- B Yıldızları
- O Yıldızları

1. Yıldızlar (Genel Bilgi)

Nükleer tepkimelerle maddeyi enerjiye çevirirler

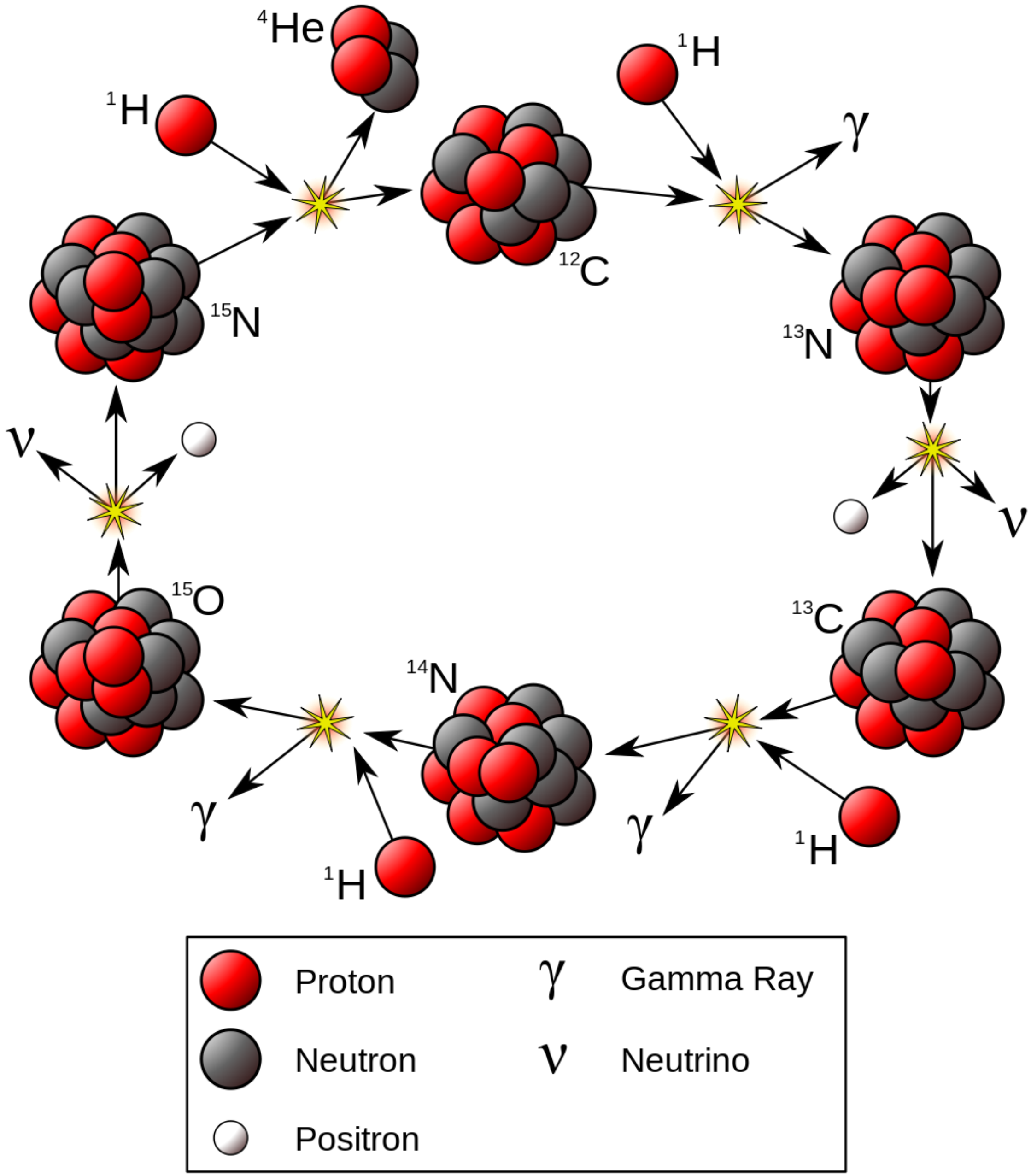
Güneş benzeri yıldızlarda

p-p çevrimi

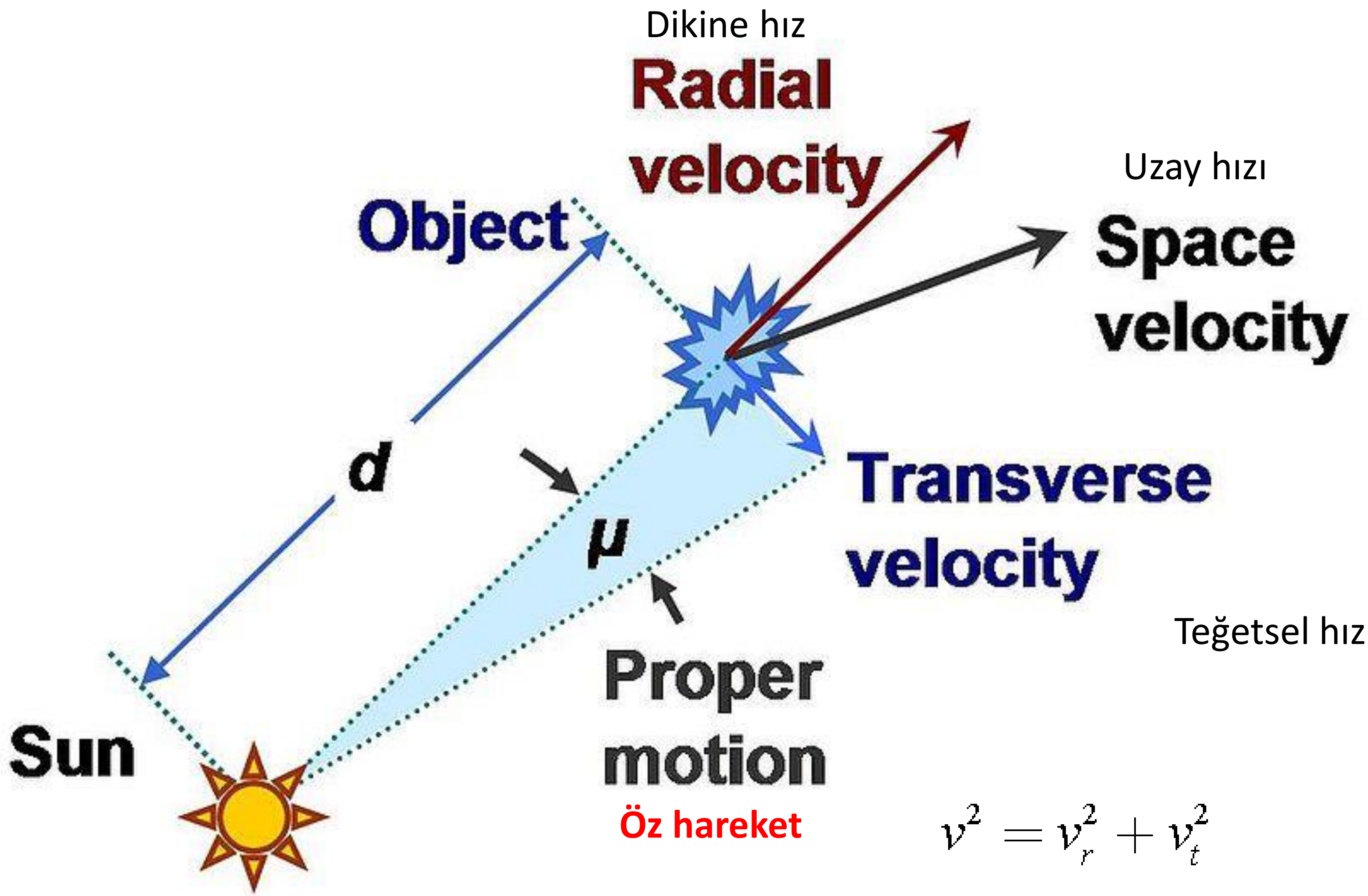


Büyük kütleli yıldızlarda

CNO çevrimi

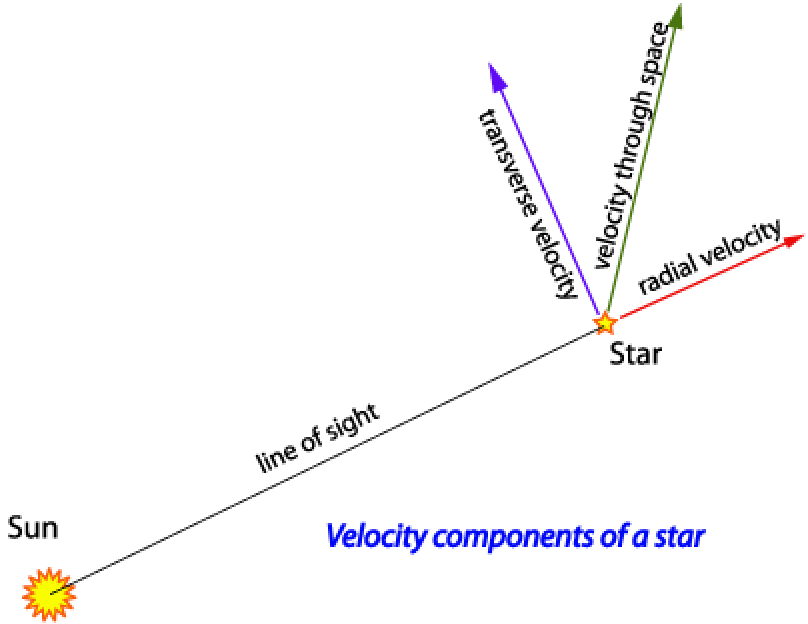


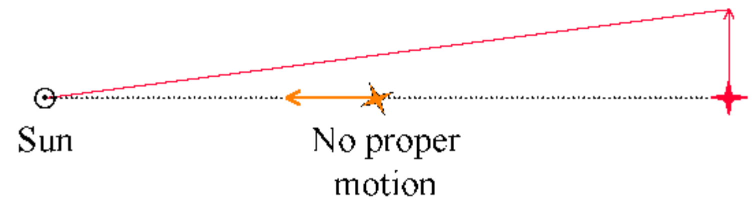
Hareket

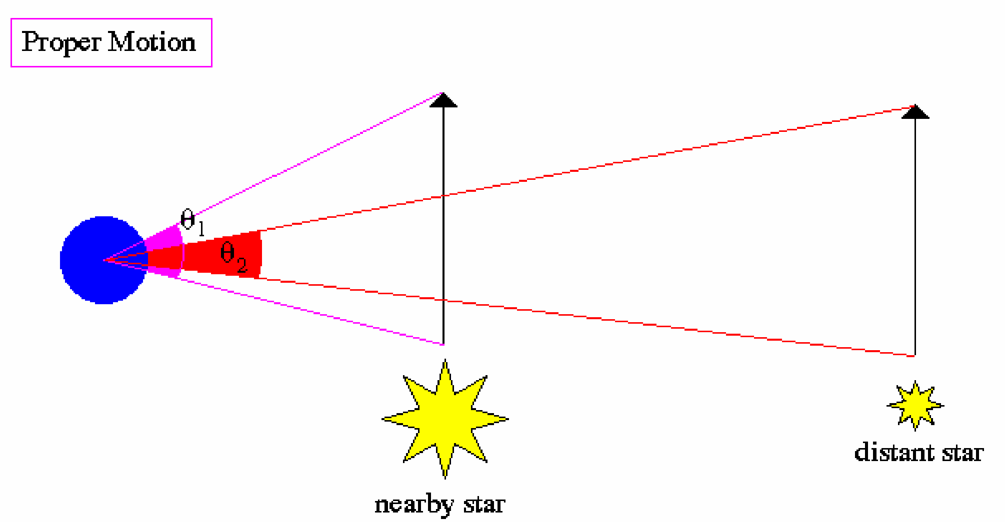


$$v^2 = v_r^2 + v_t^2$$

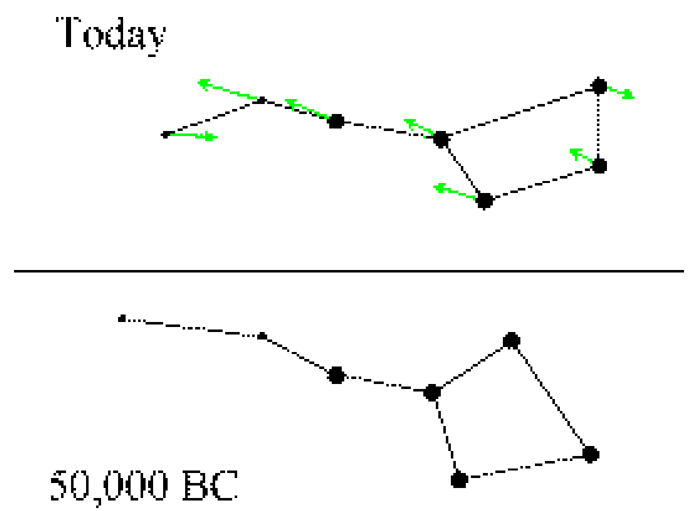
$$= v_r^2 + (4.74\mu d)^2$$

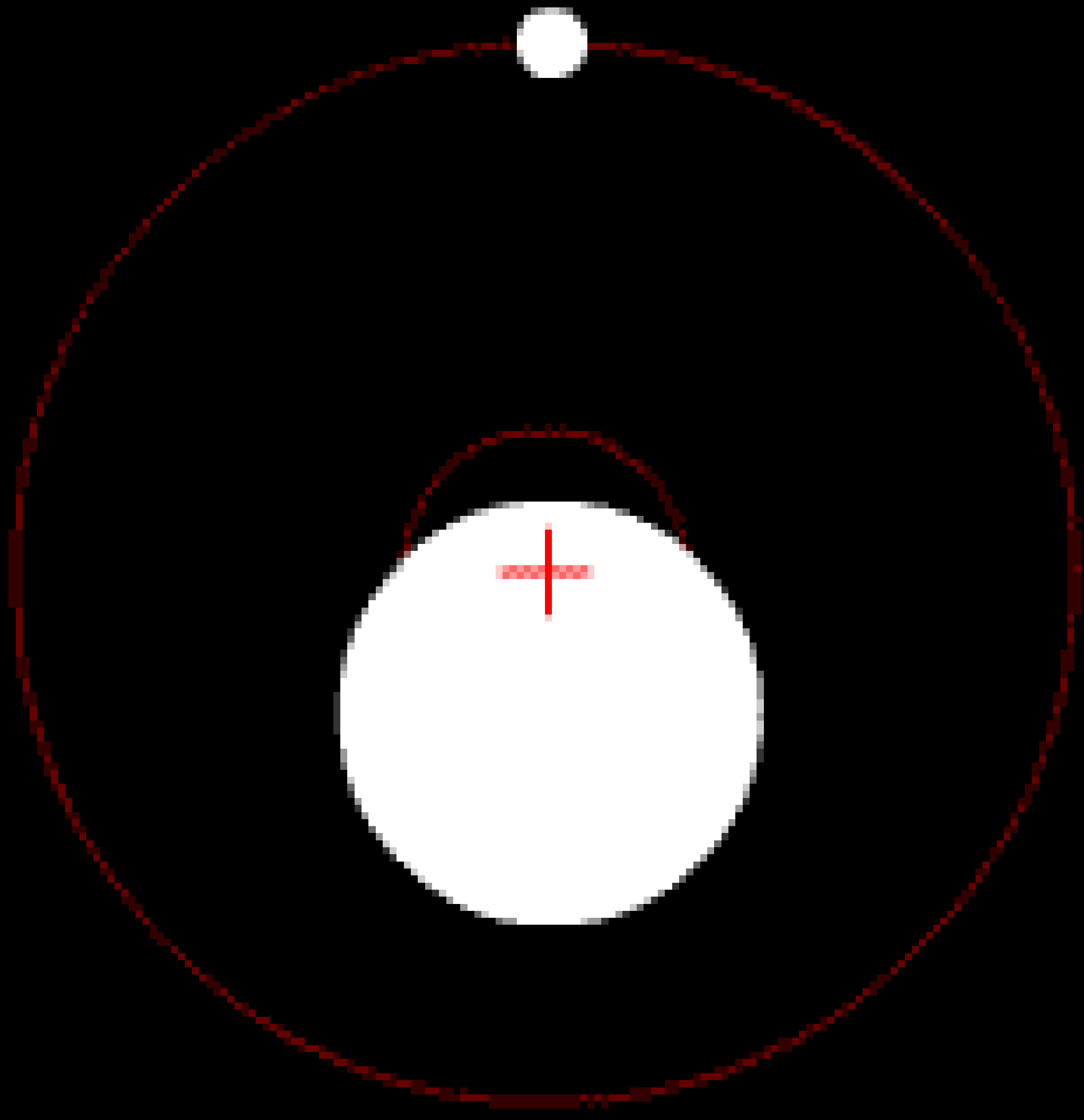


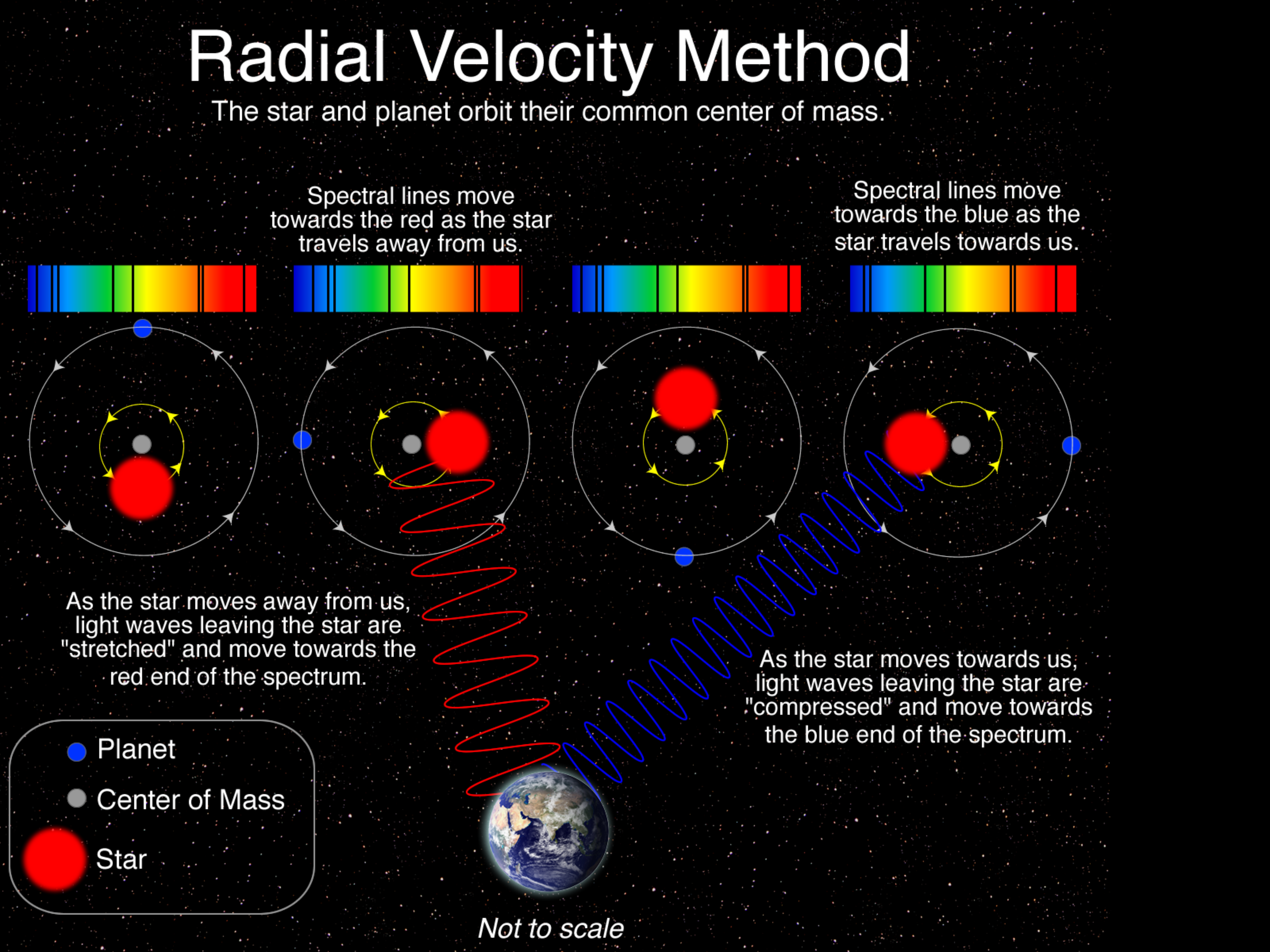


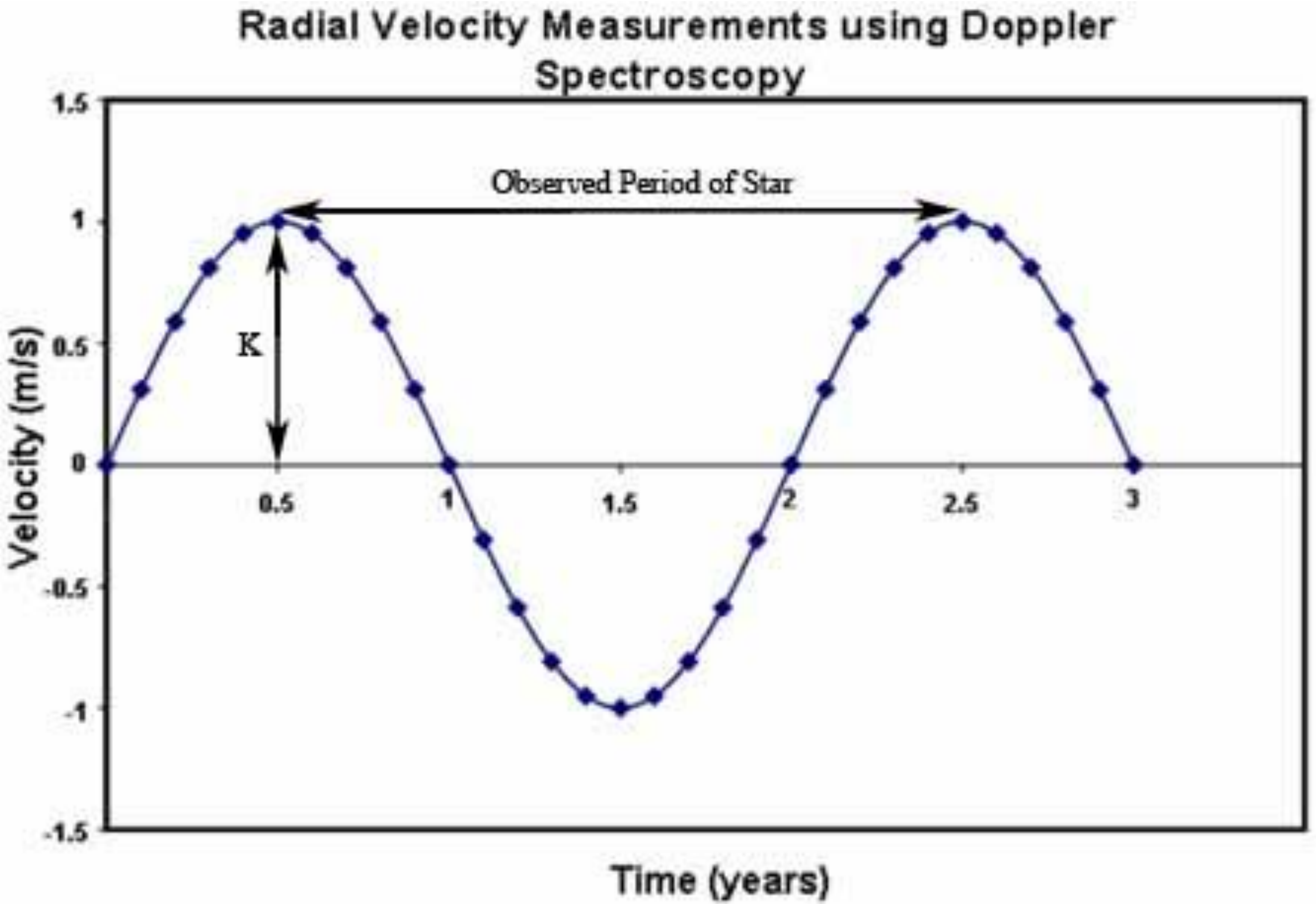


even though both stars are moving at the same velocity, the nearby star marks out a larger angle, θ_1 then the distant star's angle, θ_2

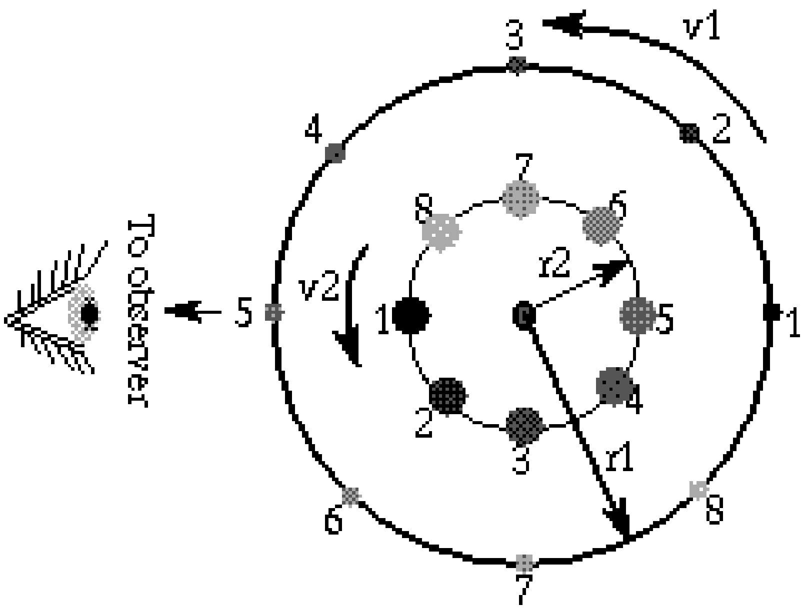




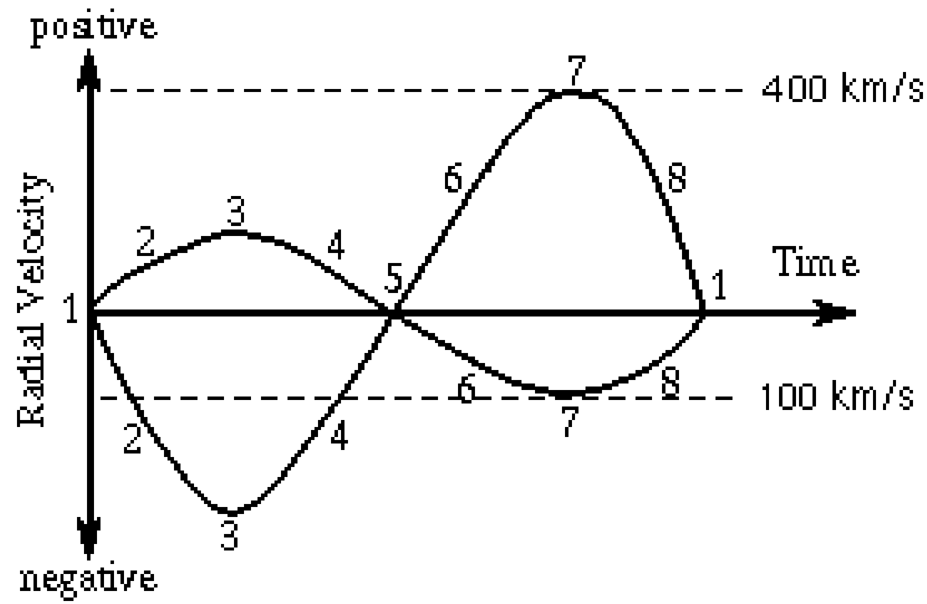

Radial Velocity Method
The star and planet orbit their common center of mass.
Spectral lines move towards the red as the star travels away from us.
Spectral lines move towards the blue as the star travels towards us.
As the star moves away from us, light waves leaving the star are "stretched" and move towards the red end of the spectrum.
As the star moves towards us, light waves leaving the star are "compressed" and move towards the blue end of the spectrum.
Planet
Center of Mass
Star
Not to scale



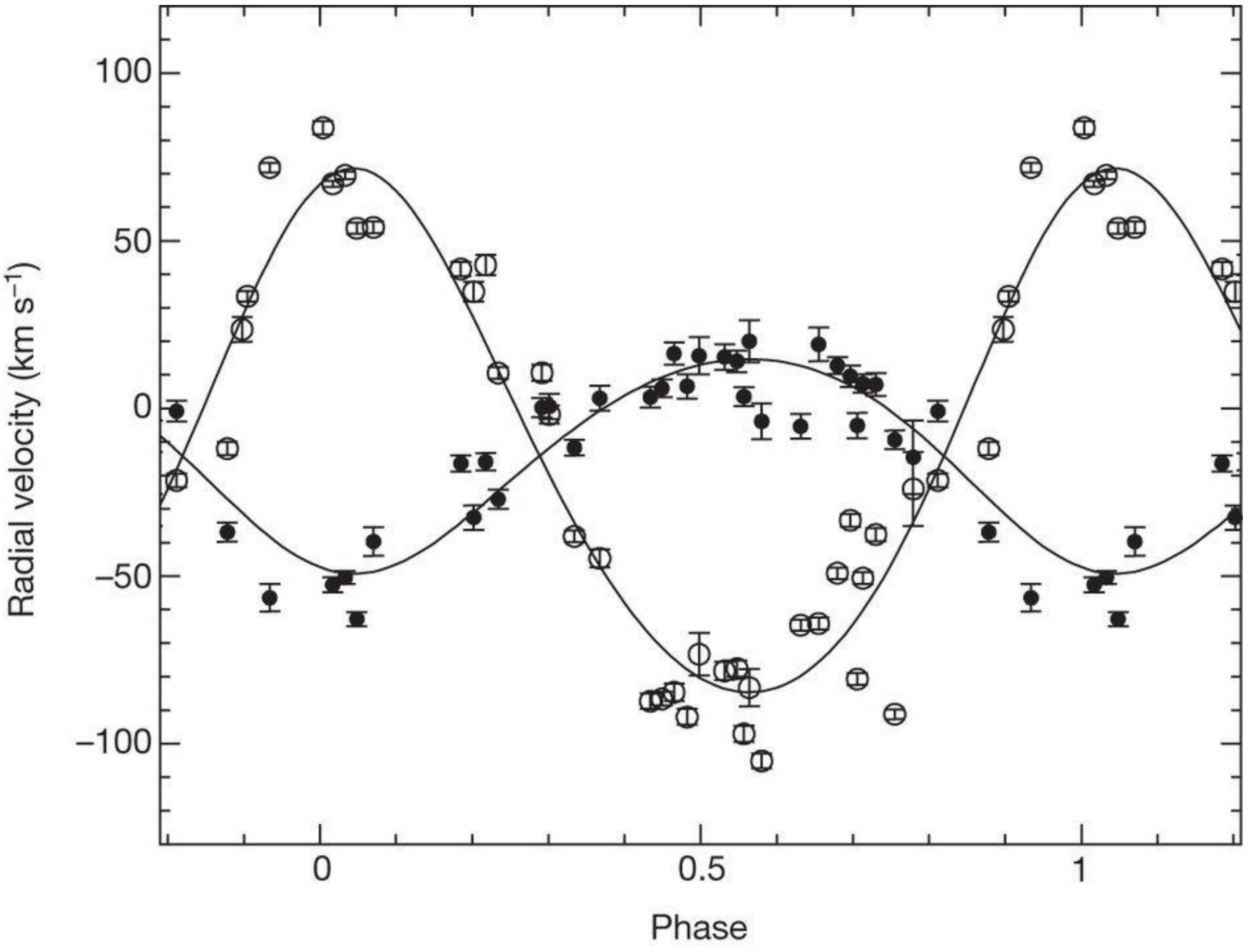
Radial Velocity Measurements using Doppler Spectroscopy
Observed Period of Star
K
Velocity (m/s)
1.5
1
0.5
0
-0.5
-1
-1.5
0.5
1
1.5
2
2.5
3
Time (years)



v1
3
2
4
7
8
6
r2
To observer
v2
5
1
5
1
5
2
4
3
r1
6
8
7

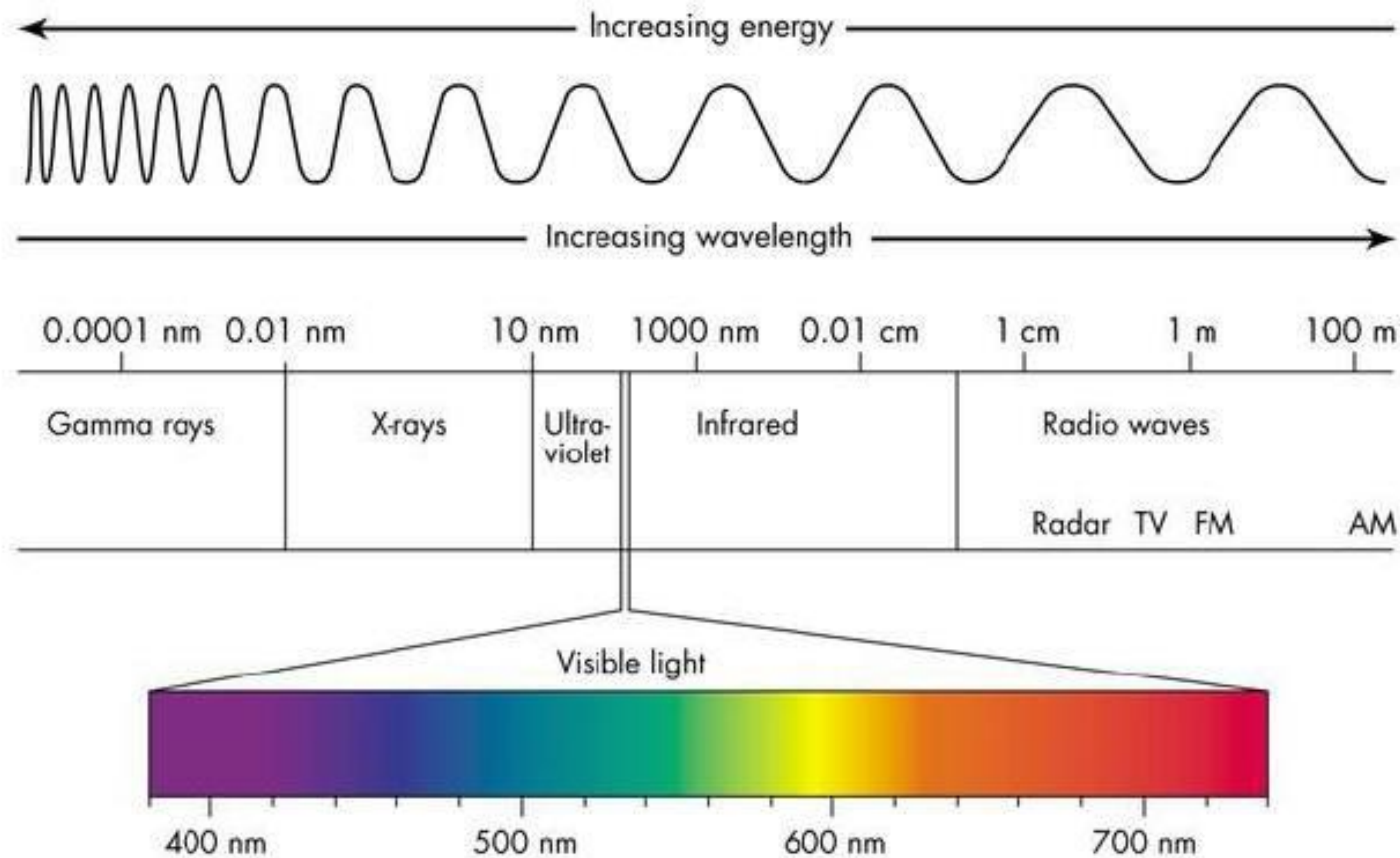


positive
7
400 km/s
Radial Velocity
6
8
3
2
4
Time
5
1
1
6
8
100 km/s
7
2
4
3
negative



100
50
0
−50
−100
Radial velocity (km s−1)
0
0.5
1
Phase

Elektromanyetik tayf



Name	Wavelength	Frequency (Hz)	Photon Energy (eV)
Gamma ray	Less than 0.01 nm	more than 10 EHz	100 kev - 300+ GeV
X - ray	0.01 - 10 nm	30 EHz - 30 PHz	120 eV - 120 keV
Ultraviolet	10 nm - 400 nm	30 PHz - 790 THz	3 eV - 124 eV
Visible	390 nm - 750 nm	790 THz - 405 THz	1.7 eV - 3.3 eV
Infrared	750 nm - 1 mm	405 THz - 300 GHz	1.24 meV -1.7 eV
Microwave	1 mm - 1 meter	300 GHz - 300 MHz	1.24 μ eV - 1.24 meV
Radio	1 mm - km	300 GHz - 3 Hz	12.4 feV - 1.24 meV

How to calculate energy for electromagnetic waves

This energy is carried in smalll packs called photons. The energy per photon of an electromagnetic wave can be calculated from the Planck–Einstein equation:

$$E = hf$$

where E is the energy, h is Planck's constant, and f is frequency

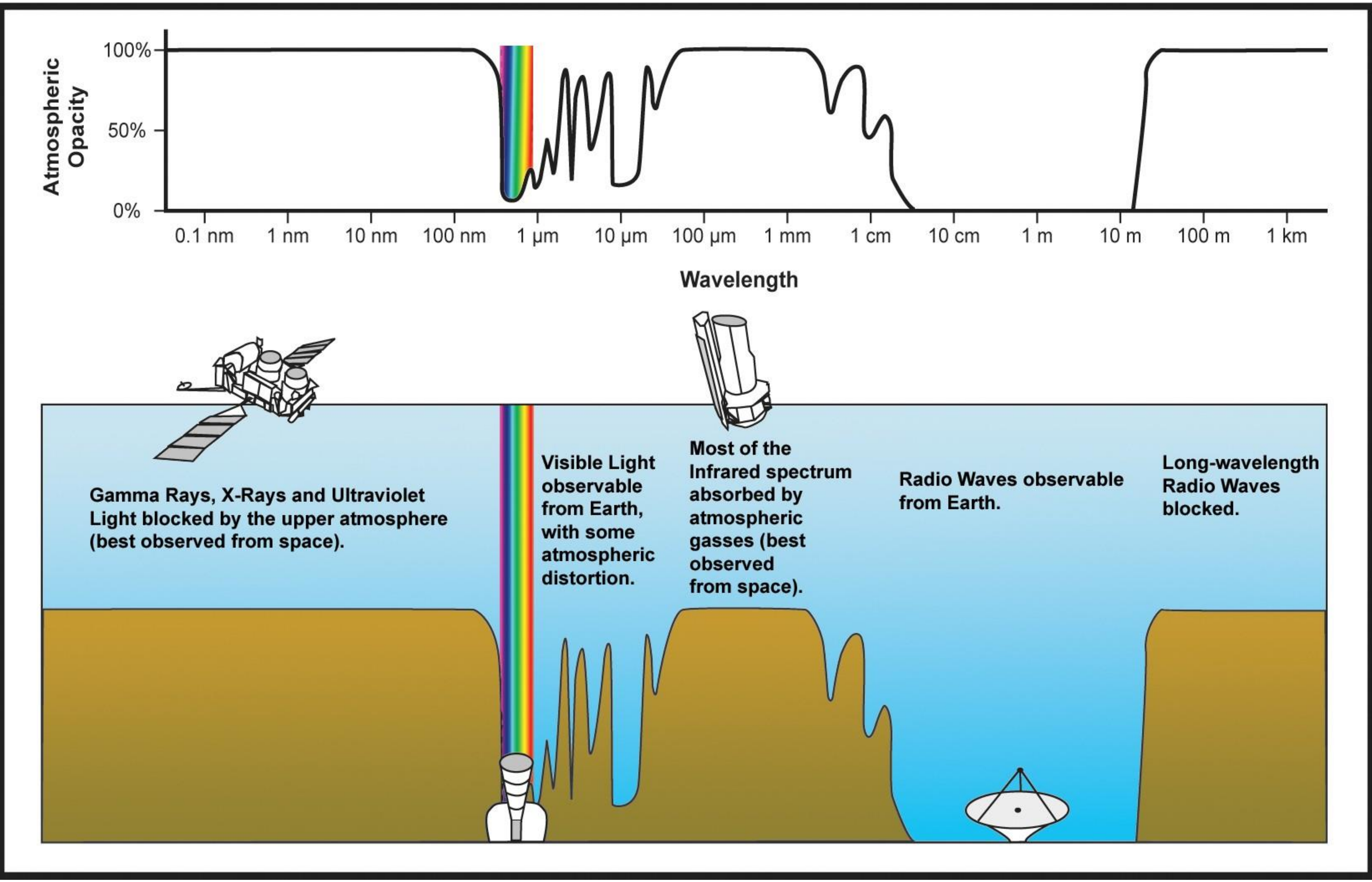
$h = 6.626 \times 10^{-34}$ joule-second

$\lambda\nu = c$ where: λ is wavelength
ν is frequency
c is the speed of light

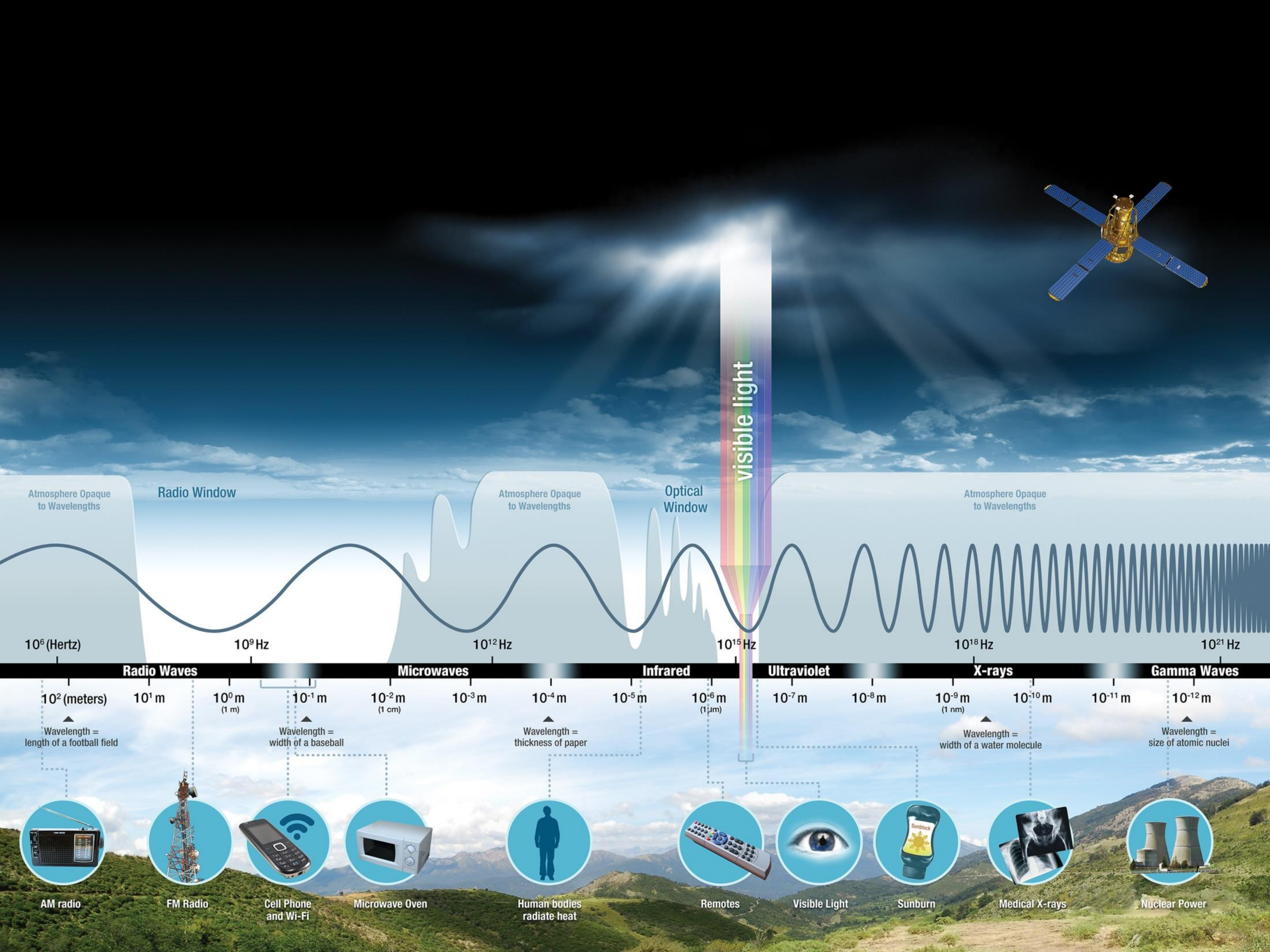
$$h = 6.6x\ 10^{-27} erg.s$$

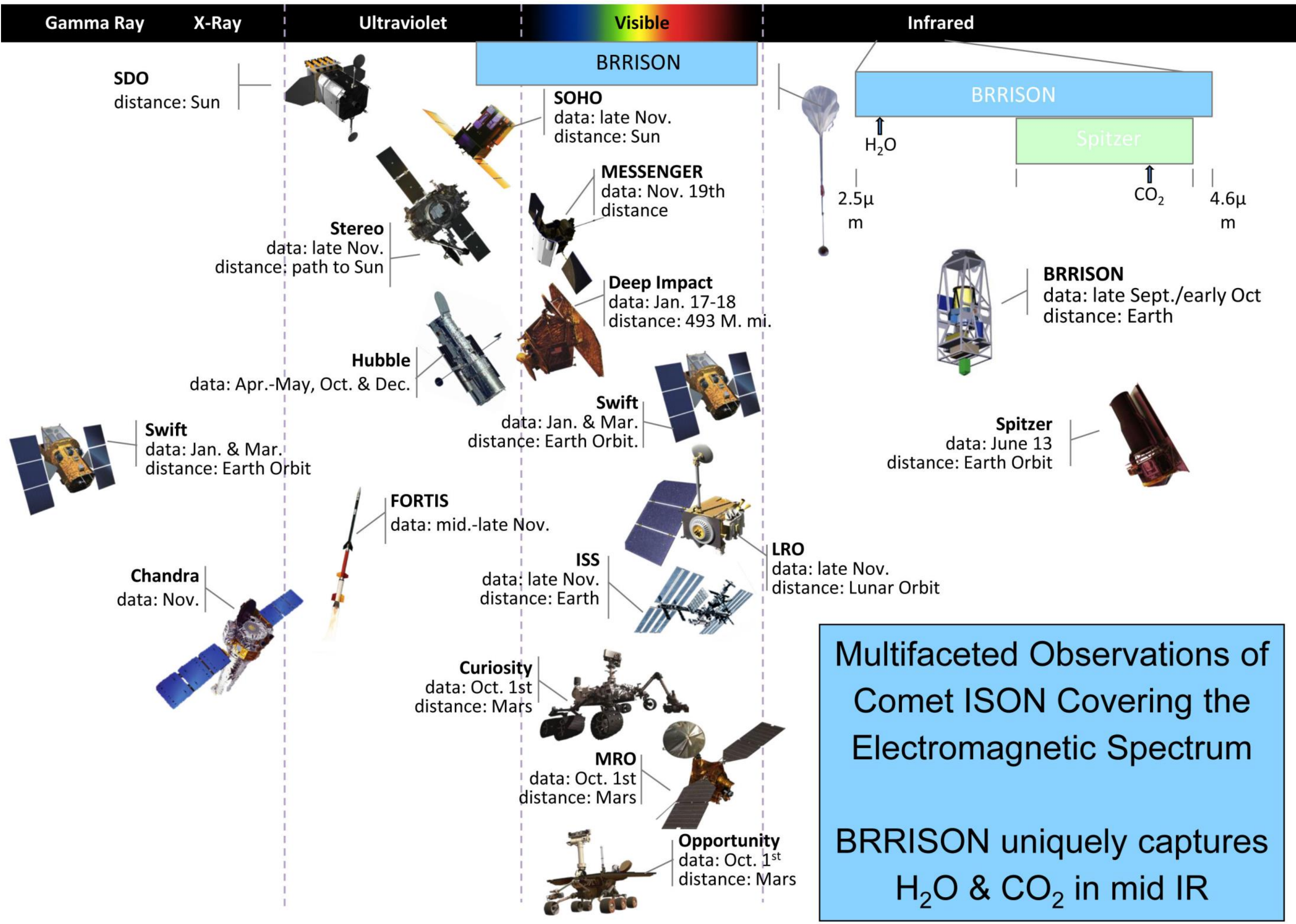
1 erg = 624150964712.04 eV

1 eV = 1.602176487E-12 erg



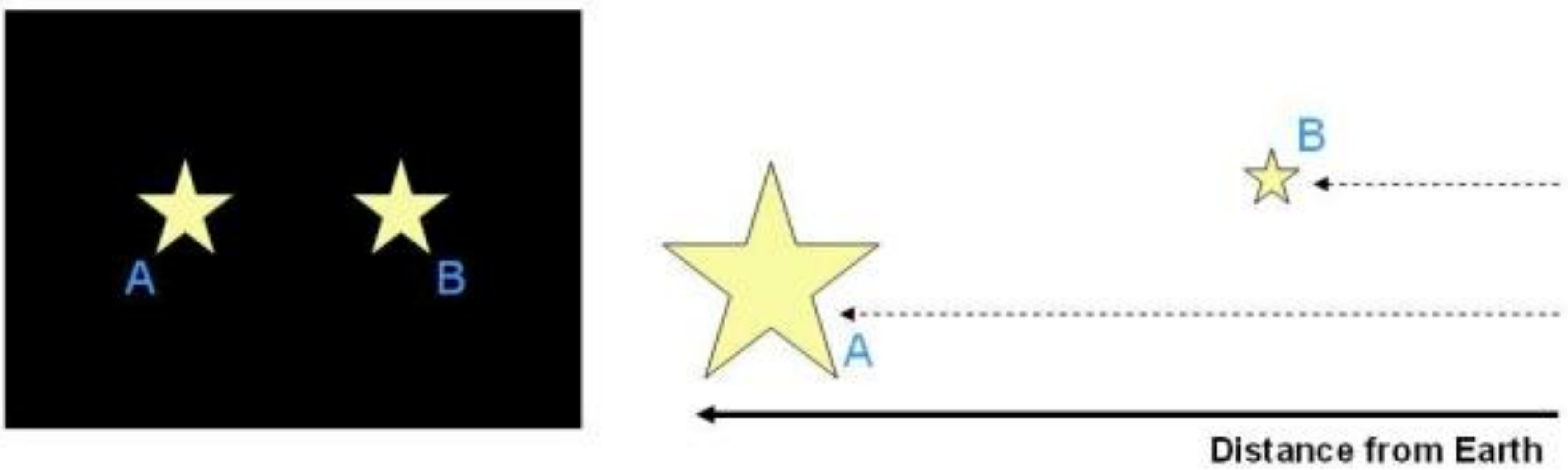
Atmospheric Opacity
100%
50%
0%
0.1 nm
1 nm
10 nm
100 nm
1 µm
10 µm
100 µm
1 mm
1 cm
10 cm
1 m
10 m
100 m
1 km
Wavelength
Gamma Rays, X-Rays and Ultraviolet Light blocked by the upper atmosphere (best observed from space).
Visible Light observable from Earth, with some atmospheric distortion.
Most of the Infrared spectrum absorbed by atmospheric gasses (best observed from space).
Radio Waves observable from Earth.
Long-wavelength Radio Waves blocked.

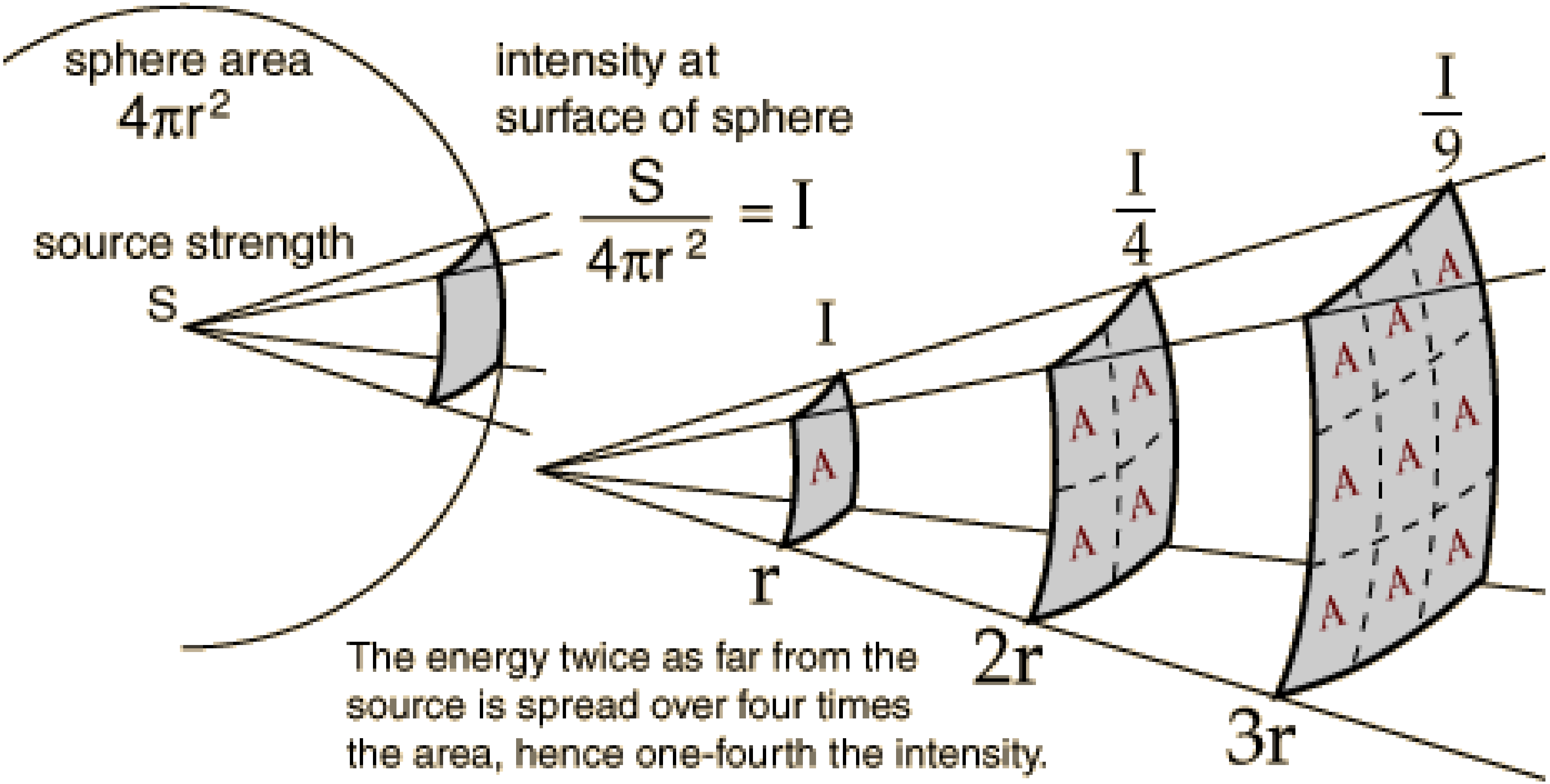

visible light
Atmosphere Opaque to Wavelengths
Radio Window
Atmosphere Opaque to Wavelengths
Optical Window
Atmosphere Opaque to Wavelengths
10^6 (Hertz)
10^9 Hz
10^{12} Hz
10^{15} Hz
10^{18} Hz
10^{21} Hz
Radio Waves
Microwaves
Infrared
Ultraviolet
X-rays
Gamma Waves
10^2 (meters)
10^1 m
10^0 m (1 m)
10^{-1} m
10^{-2} m (1 cm)
10^{-3} m
10^{-4} m
10^{-5} m
10^{-6} m (1 µm)
10^{-7} m
10^{-8} m
10^{-9} m (1 nm)
10^{-10} m
10^{-11} m
10^{-12} m
Wavelength = length of a football field
Wavelength = width of a baseball
Wavelength = thickness of paper
Wavelength = width of a water molecule
Wavelength = size of atomic nuclei
AM radio
FM Radio
Cell Phone and Wi-Fi
Microwave Oven
Human bodies radiate heat
Remotes
Visible Light
Sunburn
Medical X-rays
Nuclear Power

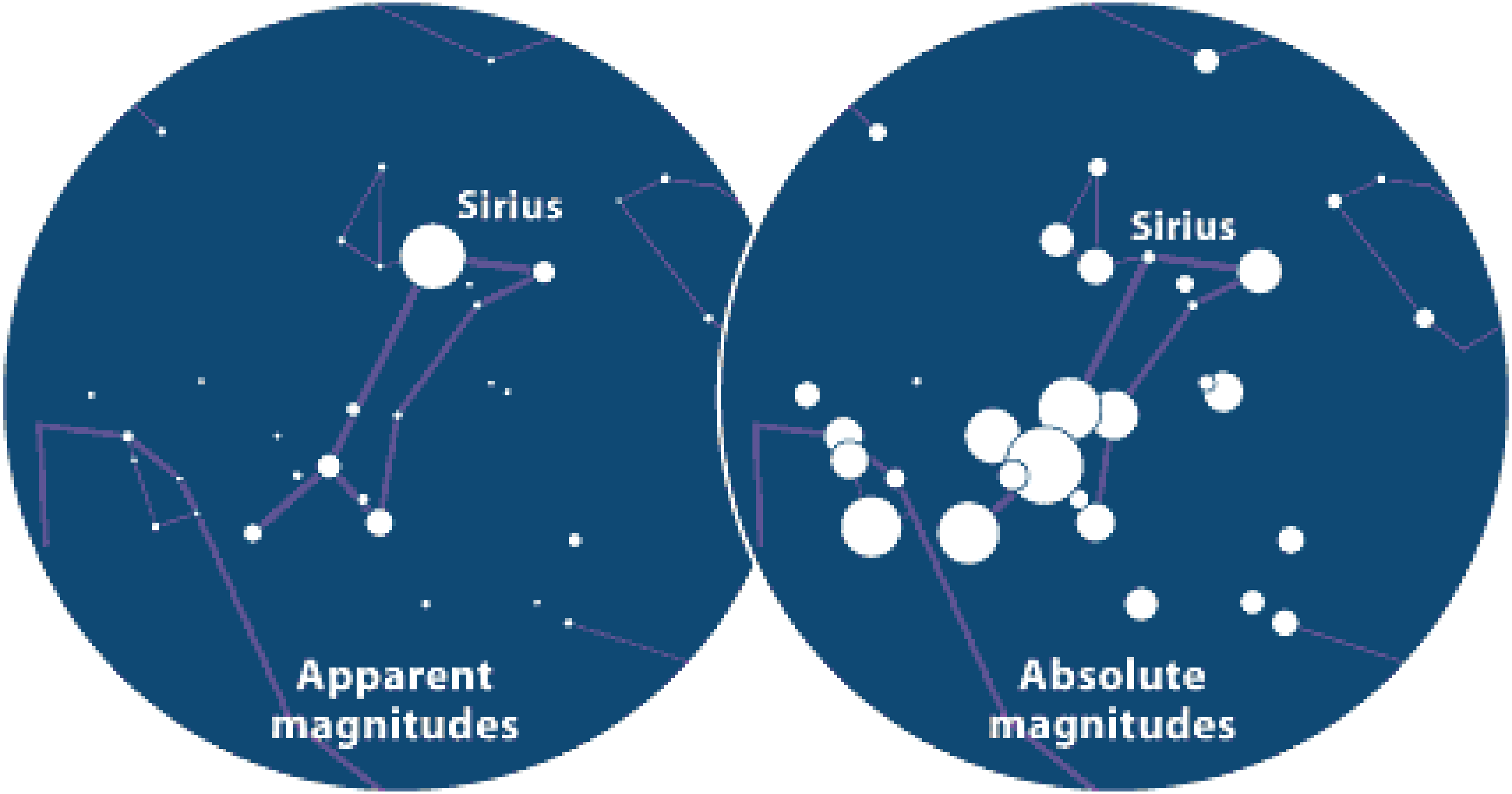


Gamma Ray
X-Ray
Ultraviolet
Visible
Infrared
BRRISON
BRRISON
Spitzer
H_2O
CO_2
2.5μ m
4.6μ m
SDO
distance: Sun
SOHO
data: late Nov.
distance: Sun
MESSENGER
data: Nov. 19th
distance
Stereo
data: late Nov.
distance: path to Sun
Deep Impact
data: Jan. 17-18
distance: 493 M. mi.
BRRISON
data: late Sept./early Oct
distance: Earth
Hubble
data: Apr.-May, Oct. & Dec.
Swift
data: Jan. & Mar.
distance: Earth Orbit.
Spitzer
data: June 13
distance: Earth Orbit
Swift
data: Jan. & Mar.
distance: Earth Orbit
FORTIS
data: mid.-late Nov.
LRO
data: late Nov.
distance: Lunar Orbit
ISS
data: late Nov.
distance: Earth
Chandra
data: Nov.
Curiosity
data: Oct. 1st
distance: Mars
MRO
data: Oct. 1st
distance: Mars
Opportunity
data: Oct. 1st
distance: Mars
Multifaceted Observations of Comet ISON Covering the Electromagnetic Spectrum
BRRISON uniquely captures H_2O & CO_2 in mid IR

Görünür parlaklık




sphere area
4πr²
intensity at
surface of sphere
S / 4πr² = I
source strength
S
I
A
r
I/4
2r
I/9
3r
The energy twice as far from the
source is spread over four times
the area, hence one-fourth the intensity.


Sirius
Apparent magnitudes
Sirius
Absolute magnitudes

Apparent Magnitude	Celestial Object
-26.7	Sun
-12.6	Full Moon
-4.4	Venus (at brightest)
-3.0	Mars (at brightest)
-1.6	Sirius (brightest star)
+3.0	Naked eye limit in an urban neighborhood
+5.5	Uranus (at brightest)
+6.0	Naked eye limit
+9.5	Faintest objects visible with binoculars
+13.7	Pluto (at brightest)
30	Faintest objects observable by the Hubble Space Telescope

Magnitudes: Definition

- Magnitude system uses apparent brightness in a *logarithmic* way. ***Apparent magnitude, m,*** defined:

  $$m = -2.5\log(F) + \text{constant}$$
  $$= -2.5\log(L/4\pi R^2) + \text{constant}$$

  (note the "–" sign to account for magnitude system)

- **so:** change of 1 mag = factor of 2.51 in apparent brightness
  change of 5 mags is a factor of 100 in apparent brightness
  fainter objects have **larger** magnitudes! (what we want)

- ***Absolute Magnitude (M)*** is defined as **Apparent Magnitude (m)** at D = 10 pc. Can show that ***distance modulus (m-M)*** is:

  $$\mathbf{(m - M) = 5\log(D) - 5}$$ where D is in pc

Apparent Magnitude

Consider two stars, 1 and 2, with apparent magnitudes m_1 and m_2 and fluxes F_1 and F_2. The relation between apparent magnitude and flux is:

$$m_1 - m_2 = -2.5\log_{10}\left(\frac{F_1}{F_2}\right)$$

$$\frac{F_1}{F_2} = 10^{(m_2 - m_1)/2.5}$$

For $m_2 - m_1 = 5$, $F_1/F_2 = 100$.

The Definition of Magnitudes

Pogson's Ratio

- A difference of five (5) magnitudes is defined as an energy ratio of 100.
- Therefore: 1 magnitude = 100**0.2 = 2.512 difference in energy.
  - $2.512^5 = 100$
- If star 1 is 1 magnitude brighter than star 2 then:

$$l_1 / l_2 = 2.512$$

where l is the received energy (ergs, *photons*).

$$m_2 - m_1 = -2.512\, log(\frac{B_2}{B_1})$$

m_1 = apparent magnitude of object 1
m_2 = apparent magnitude of object 2
B_1 = brightness of object 1
B_2 = brightness of object 2

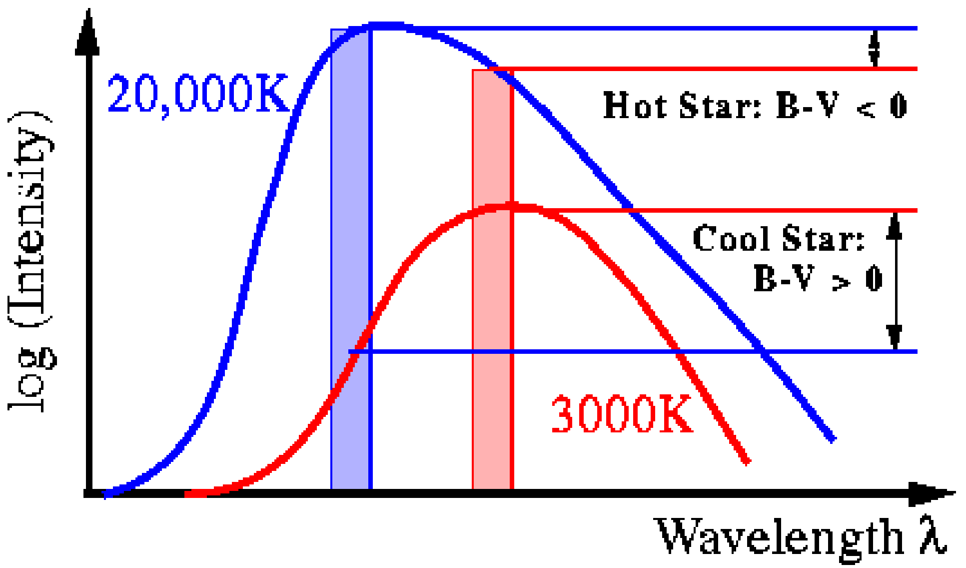
Renk Ölçeği (CI) ve Sıcaklık

Color Index

Measure "magnitude" with different filters

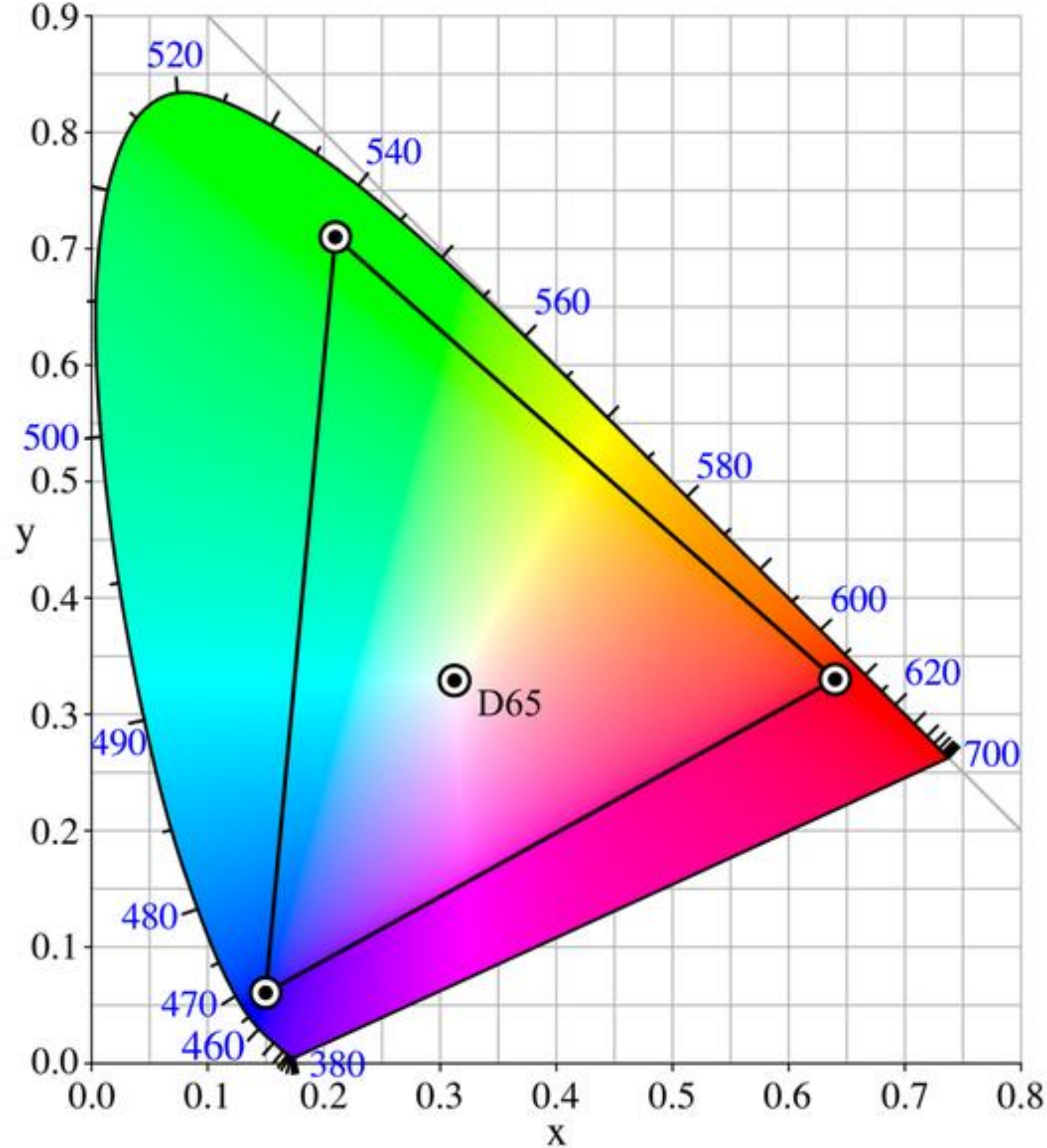
⇒ Examples are U ("ultraviolet"), B ("blue") and V ("visible")

The difference *B-V* is the "color index" *(recall Blackbody lab).*

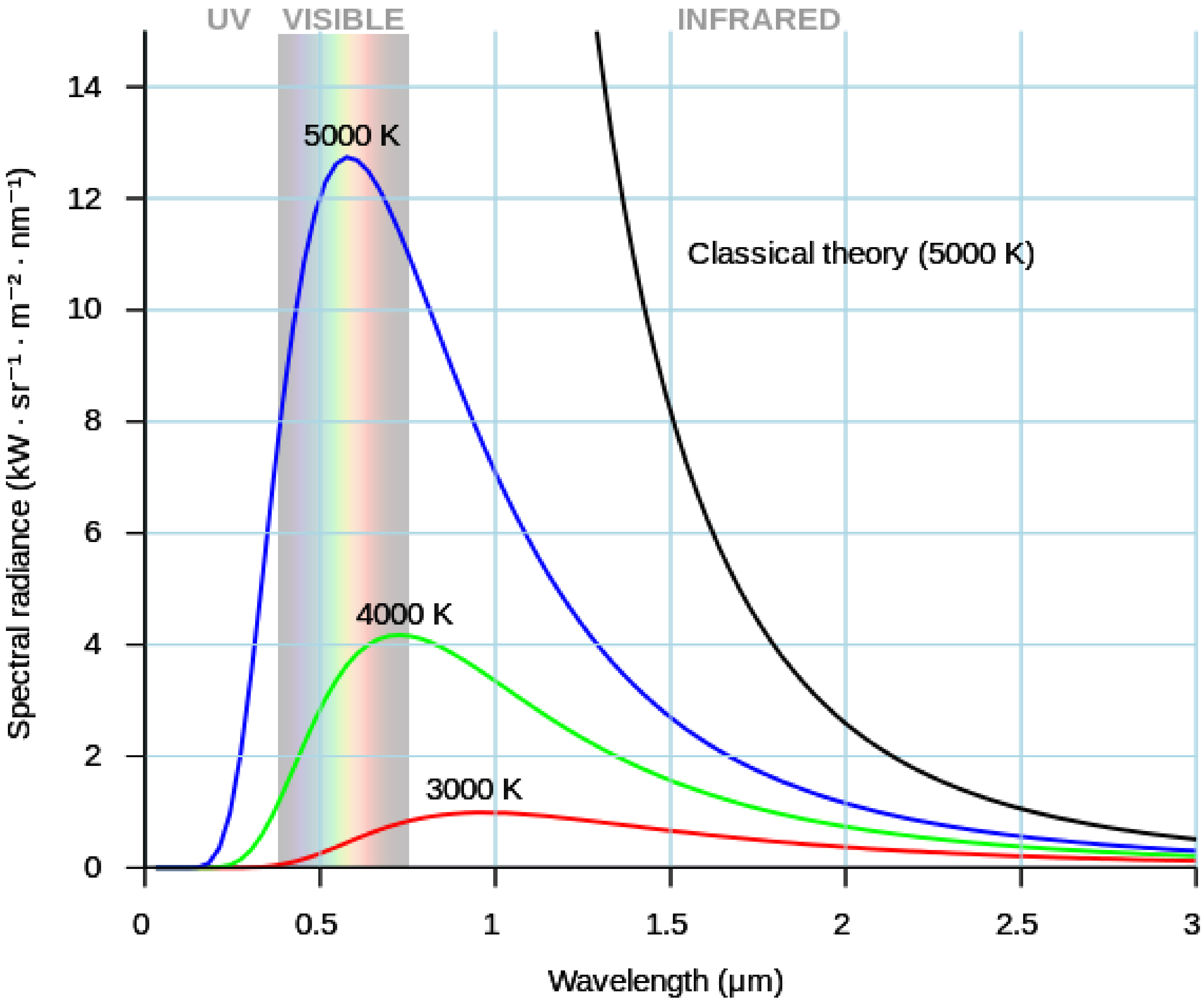


⇒ Find $T = 8540 / [(B-V) + 0.865]$ for a "Realistic star"

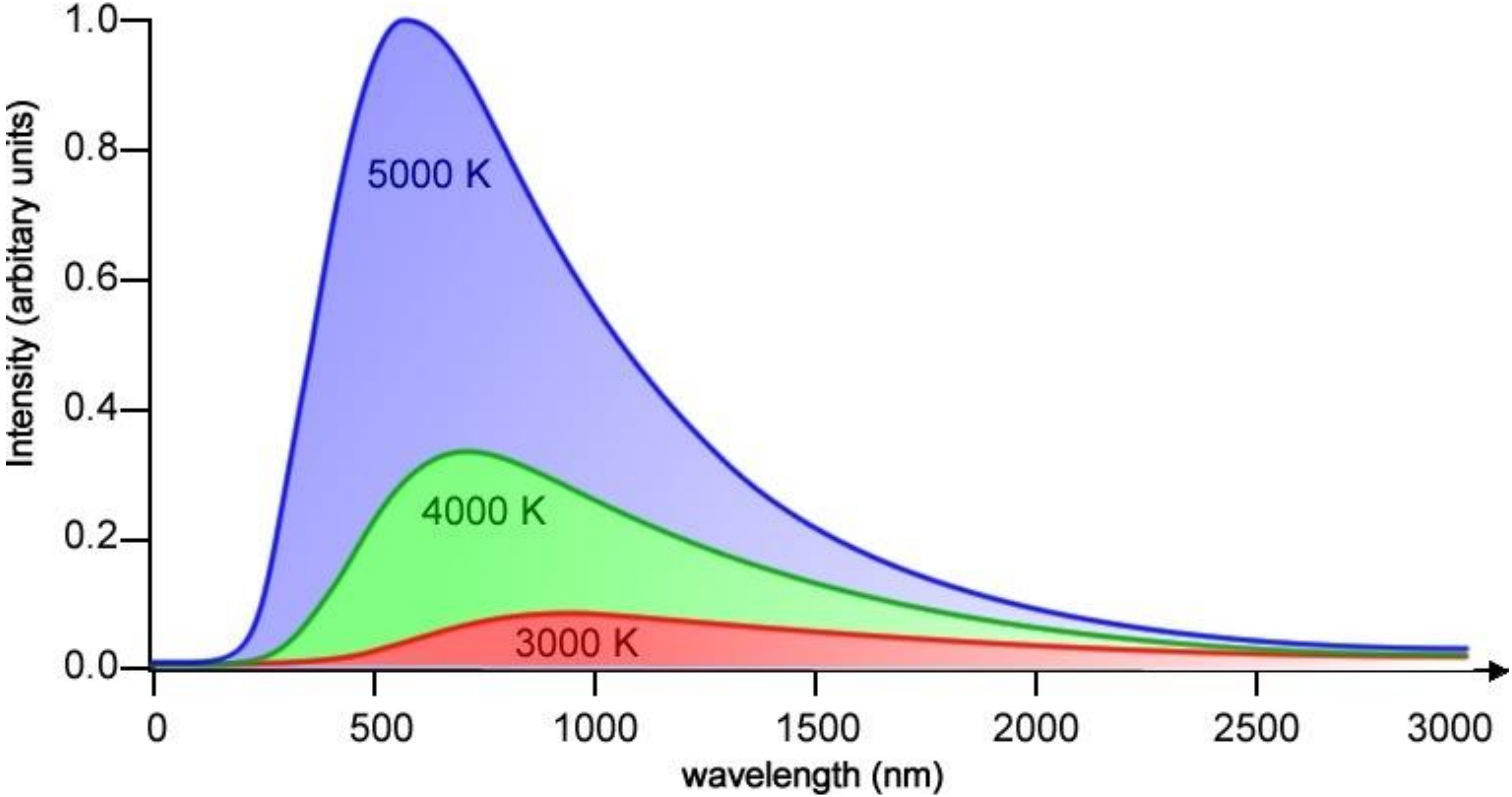
RENK UZAYI



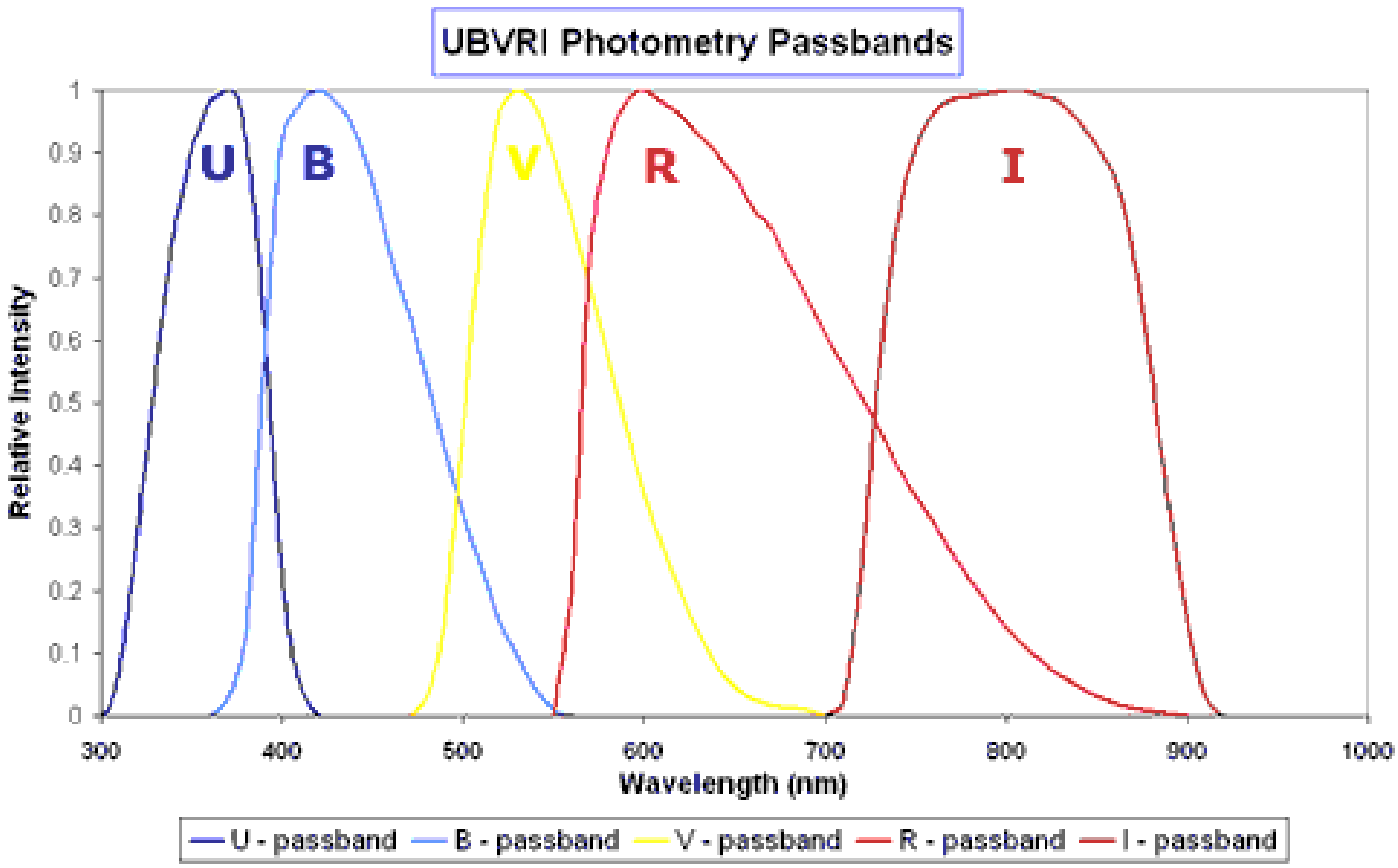
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
y
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
x
520
540
560
580
600
620
700
500
490
480
470
460
380
D65



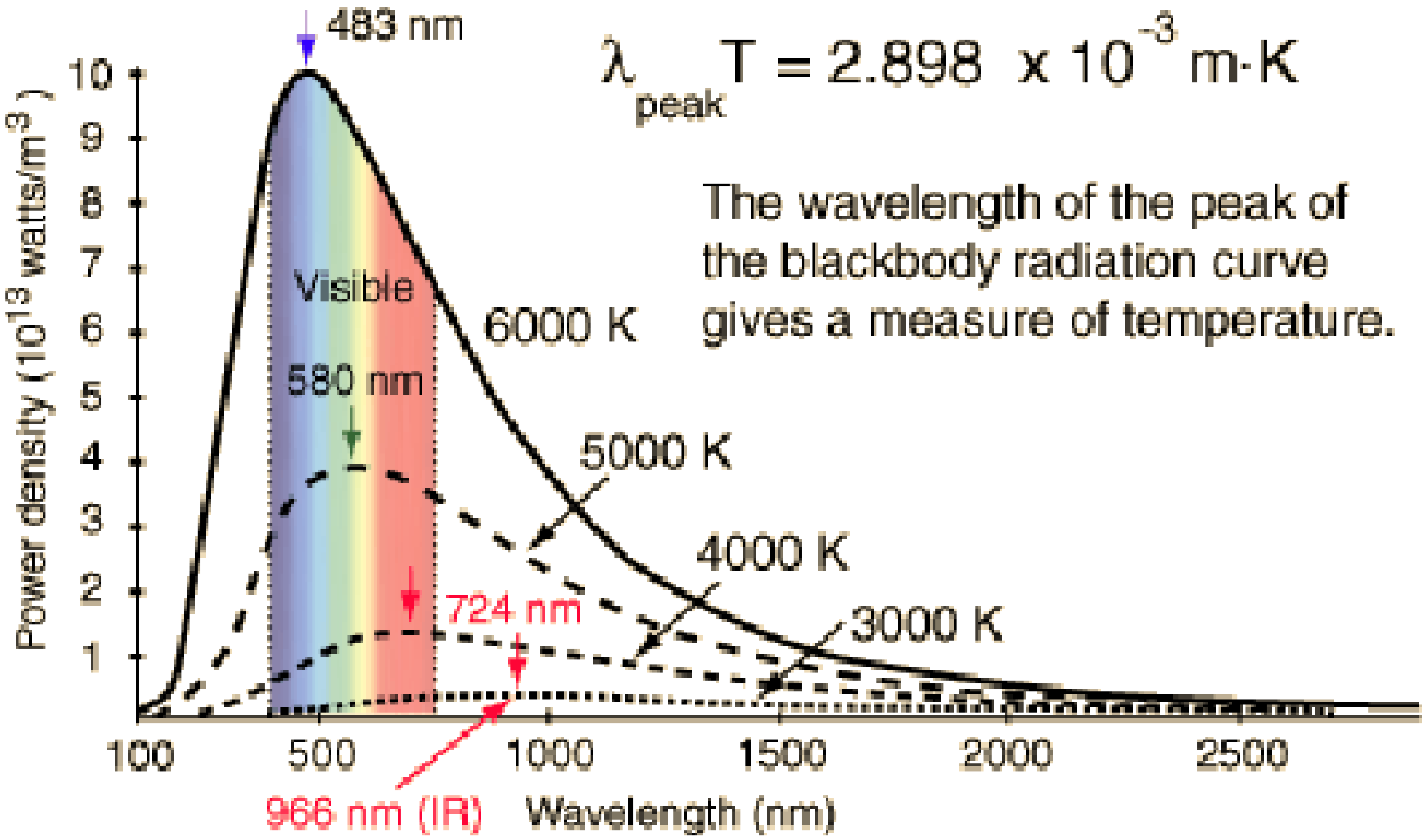
UV
VISIBLE
INFRARED
5000 K
4000 K
3000 K
Classical theory (5000 K)
Spectral radiance (kW · sr⁻¹ · m⁻² · nm⁻¹)
Wavelength (μm)
0
2
4
6
8
10
12
14
0
0.5
1
1.5
2
2.5
3



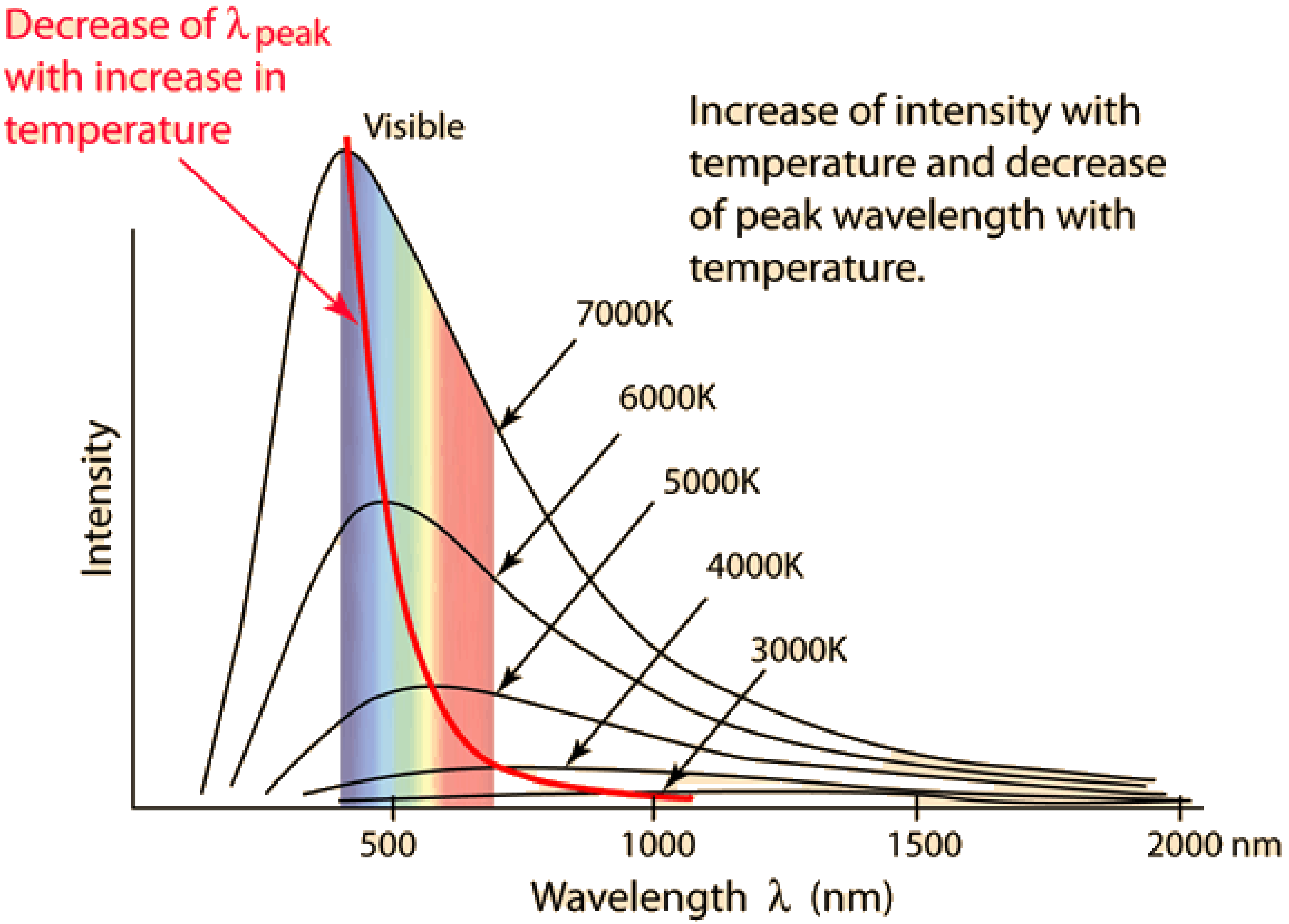
1.0
0.8
0.6
0.4
0.2
0.0
Intensity (arbitary units)
5000 K
4000 K
3000 K
0
500
1000
1500
2000
2500
3000
wavelength (nm)



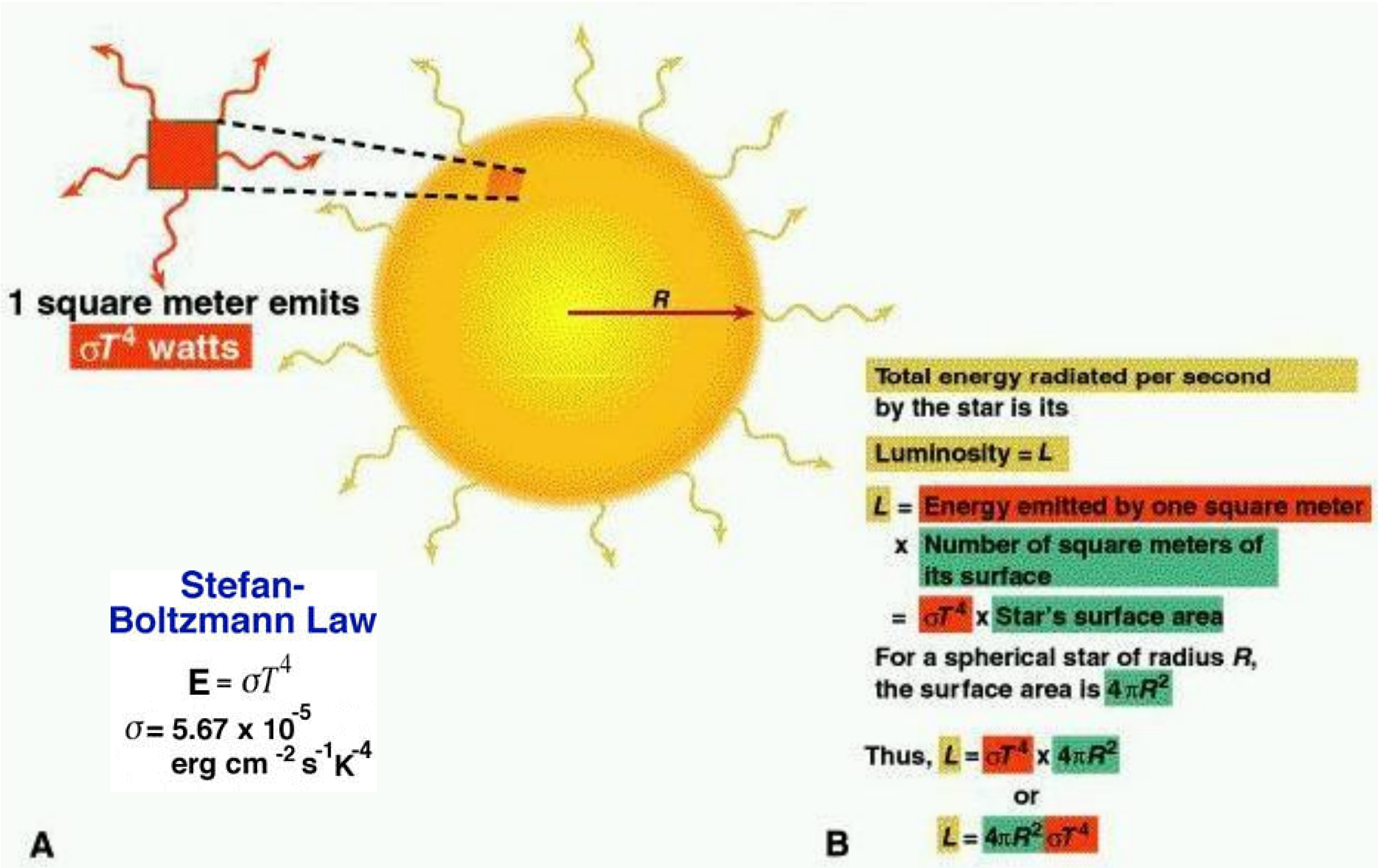
UBVRI Photometry Passbands
U
B
V
R
I
Relative Intensity
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
300
400
500
600
700
800
900
1000
Wavelength (nm)
U - passband
B - passband
V - passband
R - passband
I - passband



483 nm
$\lambda_{peak} T = 2.898 \times 10^{-3}$ m·K
The wavelength of the peak of the blackbody radiation curve gives a measure of temperature.
Power density (10^{13} watts/m^3)
10
9
8
7
6
5
4
3
2
1
Visible
6000 K
580 nm
5000 K
4000 K
724 nm
3000 K
100
500
1000
1500
2000
2500
966 nm (IR)
Wavelength (nm)


Decrease of λ peak
with increase in
temperature
Visible
Increase of intensity with
temperature and decrease
of peak wavelength with
temperature.
7000K
6000K
5000K
4000K
3000K
Intensity
500
1000
1500
2000 nm
Wavelength λ (nm)

Stefan-Boltzmann Yasası ve Işıtma (Işınım Gücü)



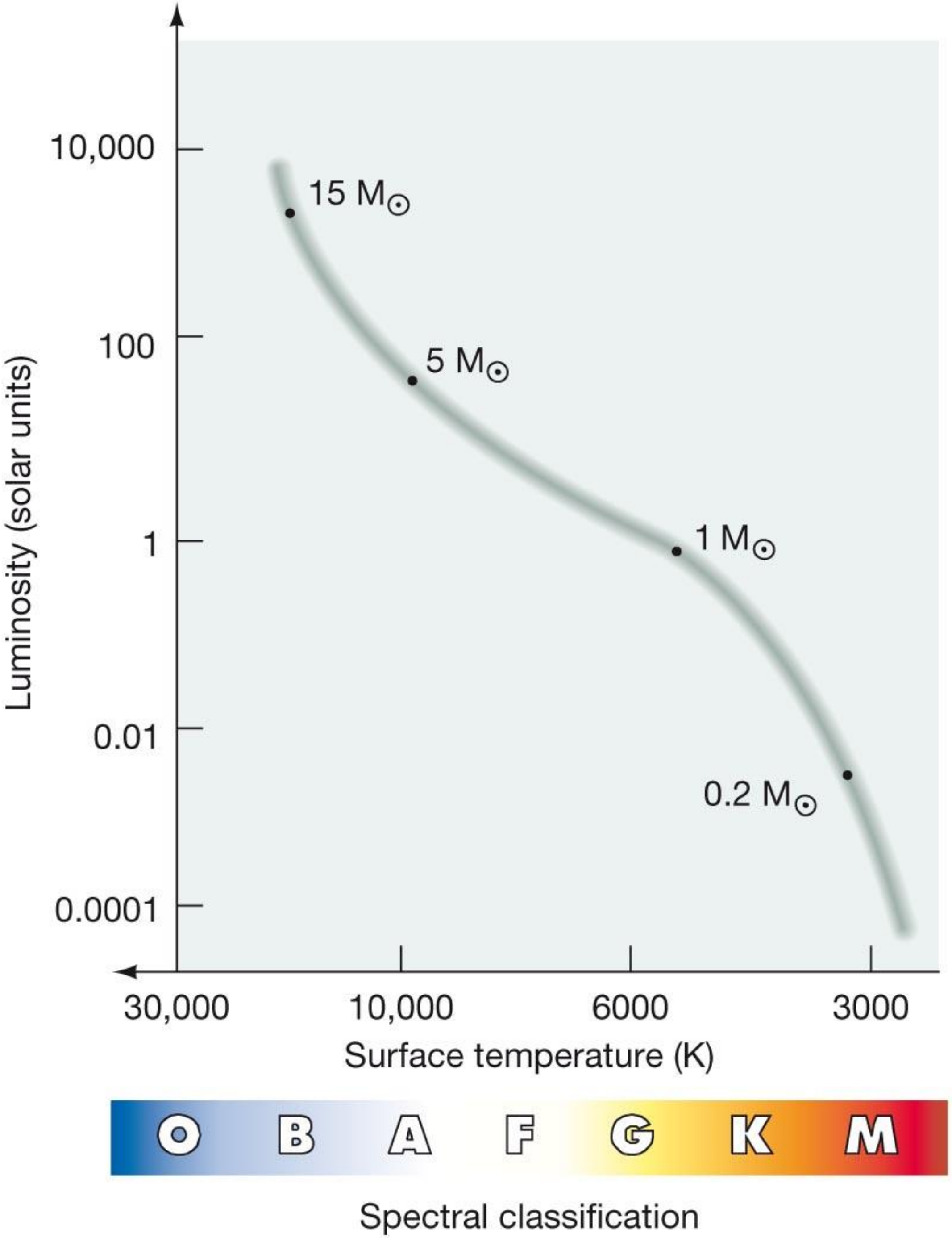
Wien's law

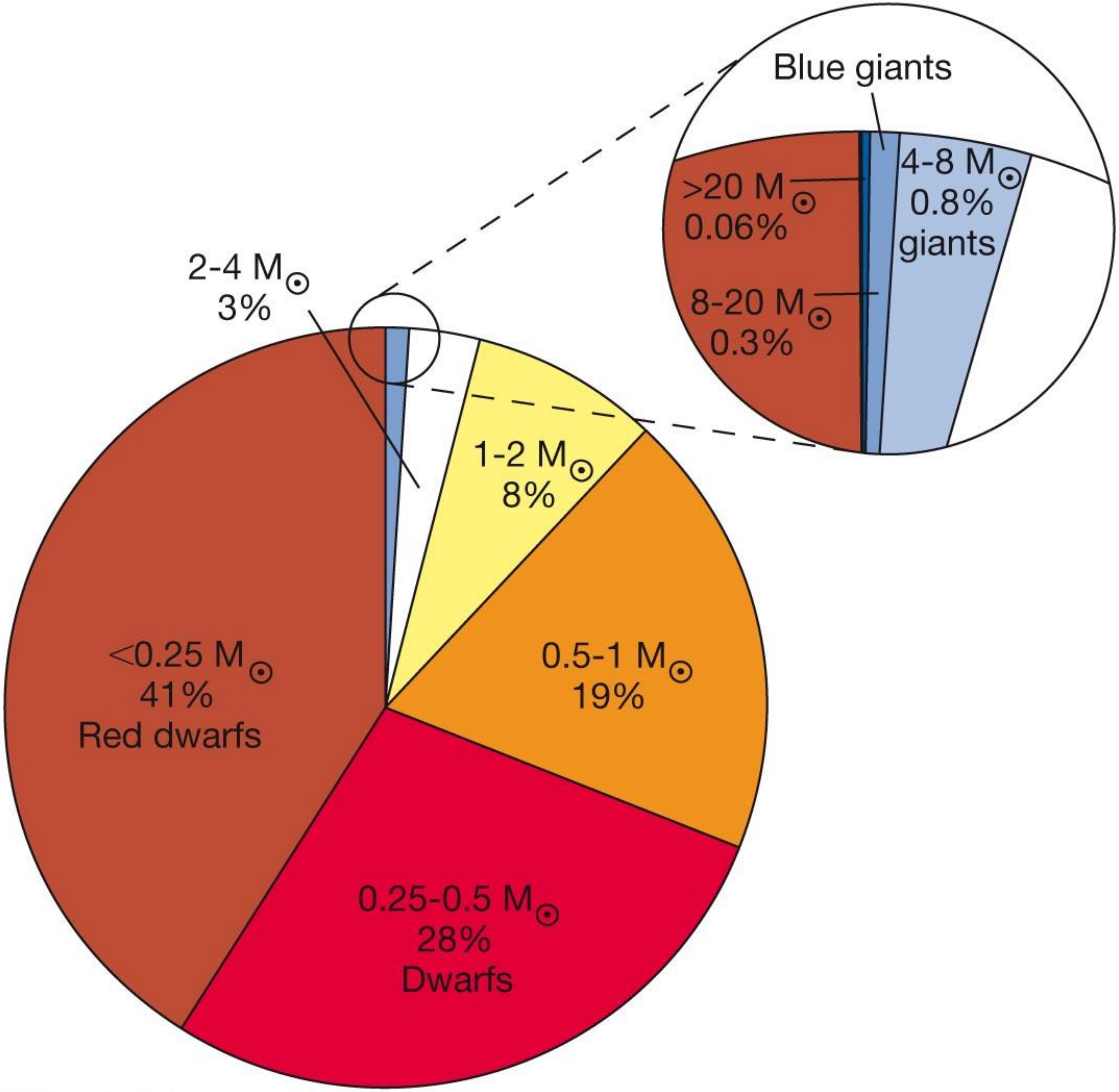
Color ↔ Temp.

Stefan-Boltzmann law

$\text{Lum.} = \text{Size} \times \text{Temp.}^4$

Anakol üzerinde kütle dağılımı




Blue giants
>20 M☉
0.06%
8-20 M☉
0.3%
4-8 M☉
0.8%
giants
2-4 M☉
3%
1-2 M☉
8%
0.5-1 M☉
19%
<0.25 M☉
41%
Red dwarfs
0.25-0.5 M☉
28%
Dwarfs

Yıldızların Ölçümü üzerine yararlı bir sayfa

http://pages.uoregon.edu/jimbrau/astr122/Notes/Chapter17.html#mass