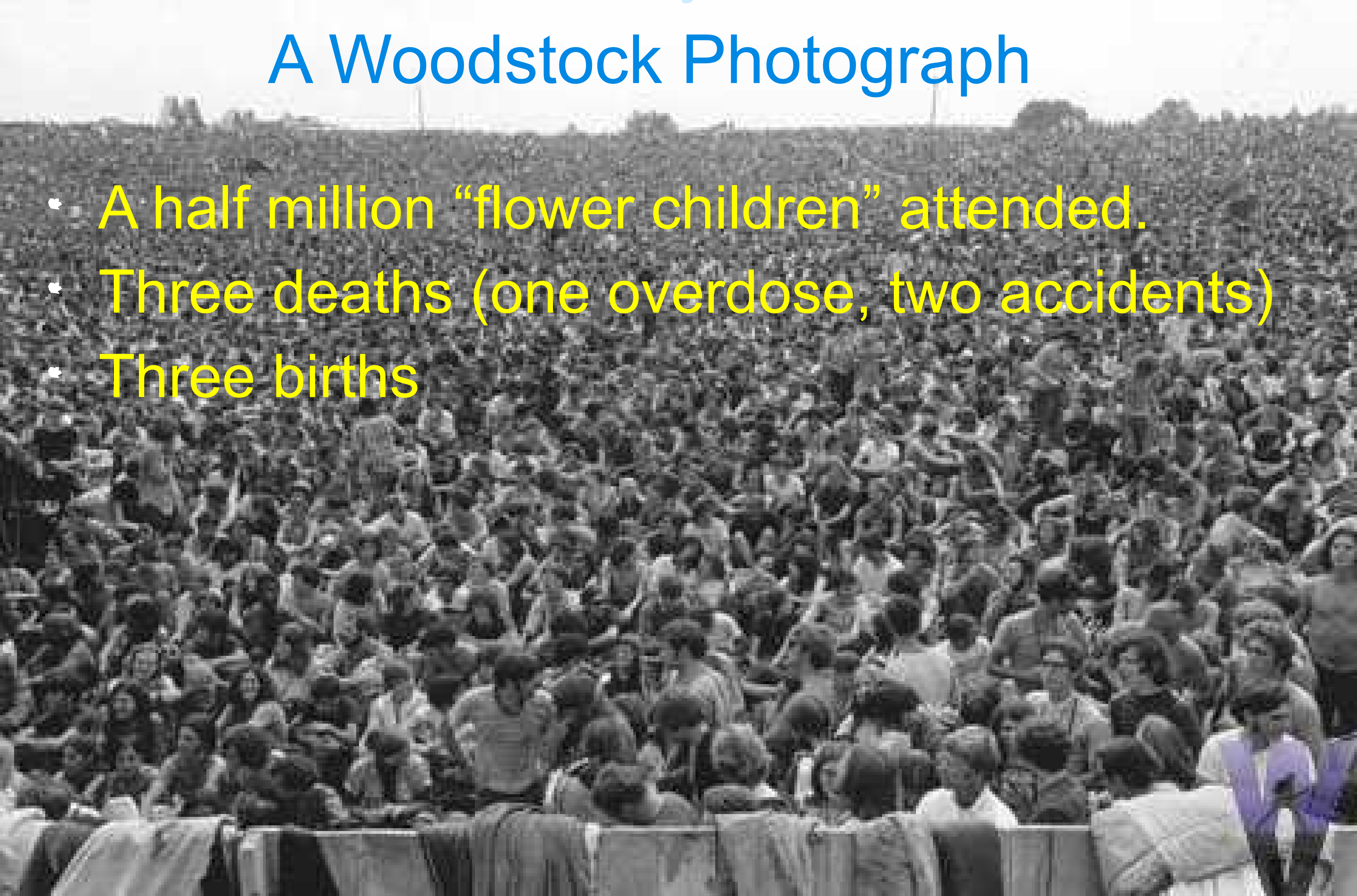
Stars

HOW CAN WE STUDY THE STARS?

Astro paparazzi

How can we Study the other Stars?

A Woodstock Photograph



- A half million “flower children” attended.
- Three deaths (one overdose, two accidents)
- Three births

How can we Study the Stars?

- A star can live for millions to billions of years.
  - we will never observe a particular star evolve from birth to death so how can we study stellar evolution?
- The key is that all stars were not born at the same time.
  - the stars which we see today are at different stages in their lives
  - we observe only a brief moment in any one star's life
  - by studying large numbers of stars, we get a "snapshot" of one moment in the history of the stellar community
- The stars we observe also have different masses.
  - by counting stars of different masses, we can determine how long stars of a given mass remain in a certain stage of life

Naming the Stars

- Star names were originally based on:
  - their brightness
  - their location in the sky

Order of brightness within a constellation

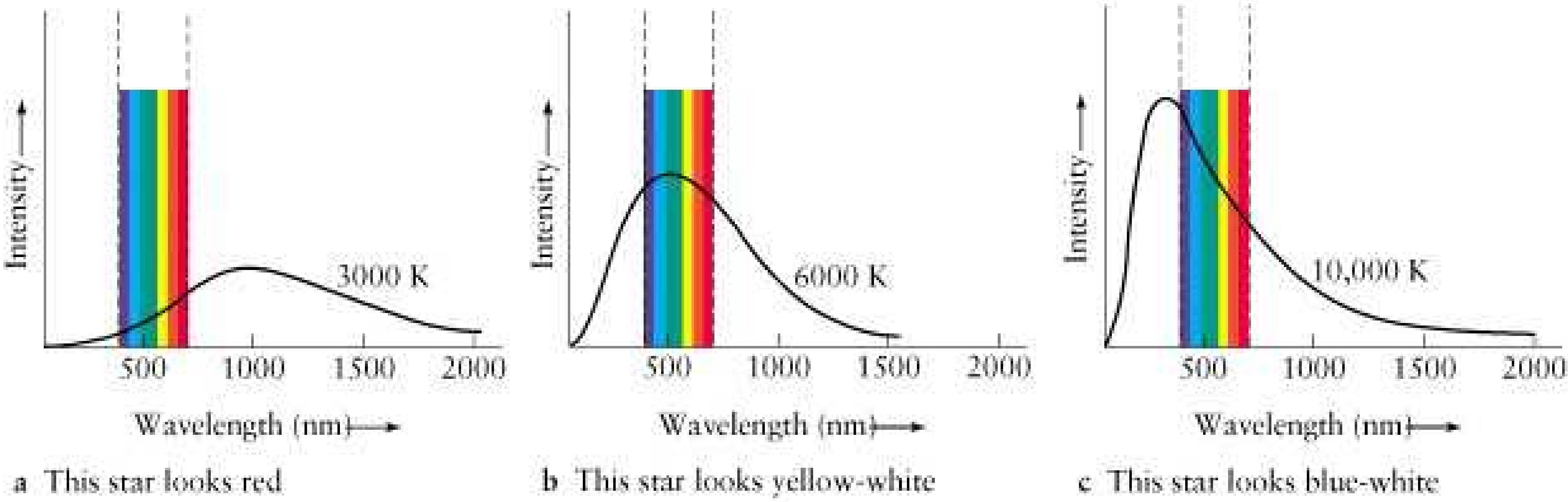
Latin Genitive of the constellation

Orionis

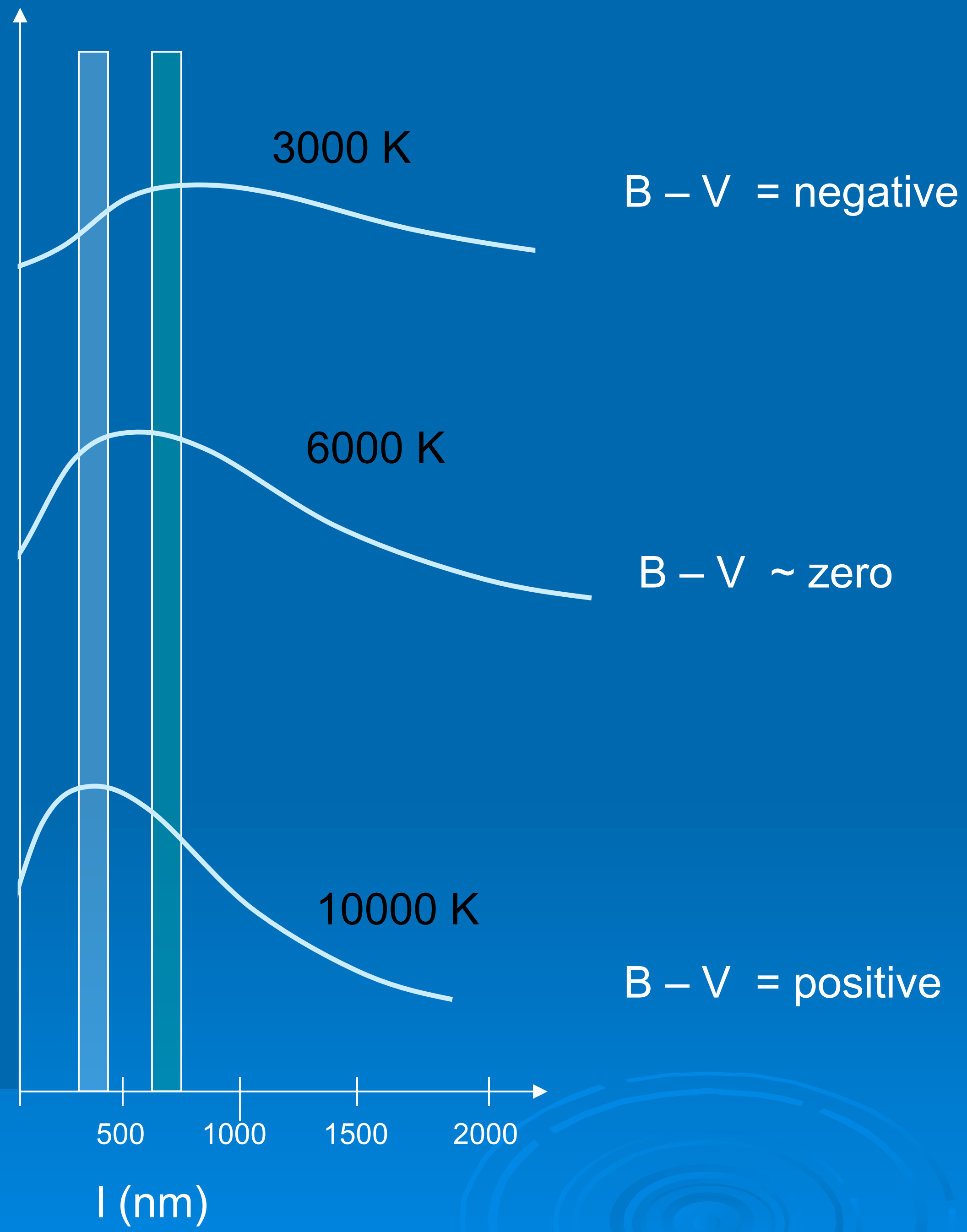
Geminorum

- These names told us little about a star’s true (physical) nature.
  - a star could be very bright because is was very close to us; not because it was truly bright
  - two stars in the same constellation might not be close to each other; one could be much farther away
- In the 20th Century, astronomers developed a classification system based on:
  - a star’s **luminosity**
  - a star’s **surface temperature**
- Since these properties depend on a star’s mass and its stage in life:
  - measuring them allows us to reconstruct stellar life cycles

A star's color reveals its surface temperature

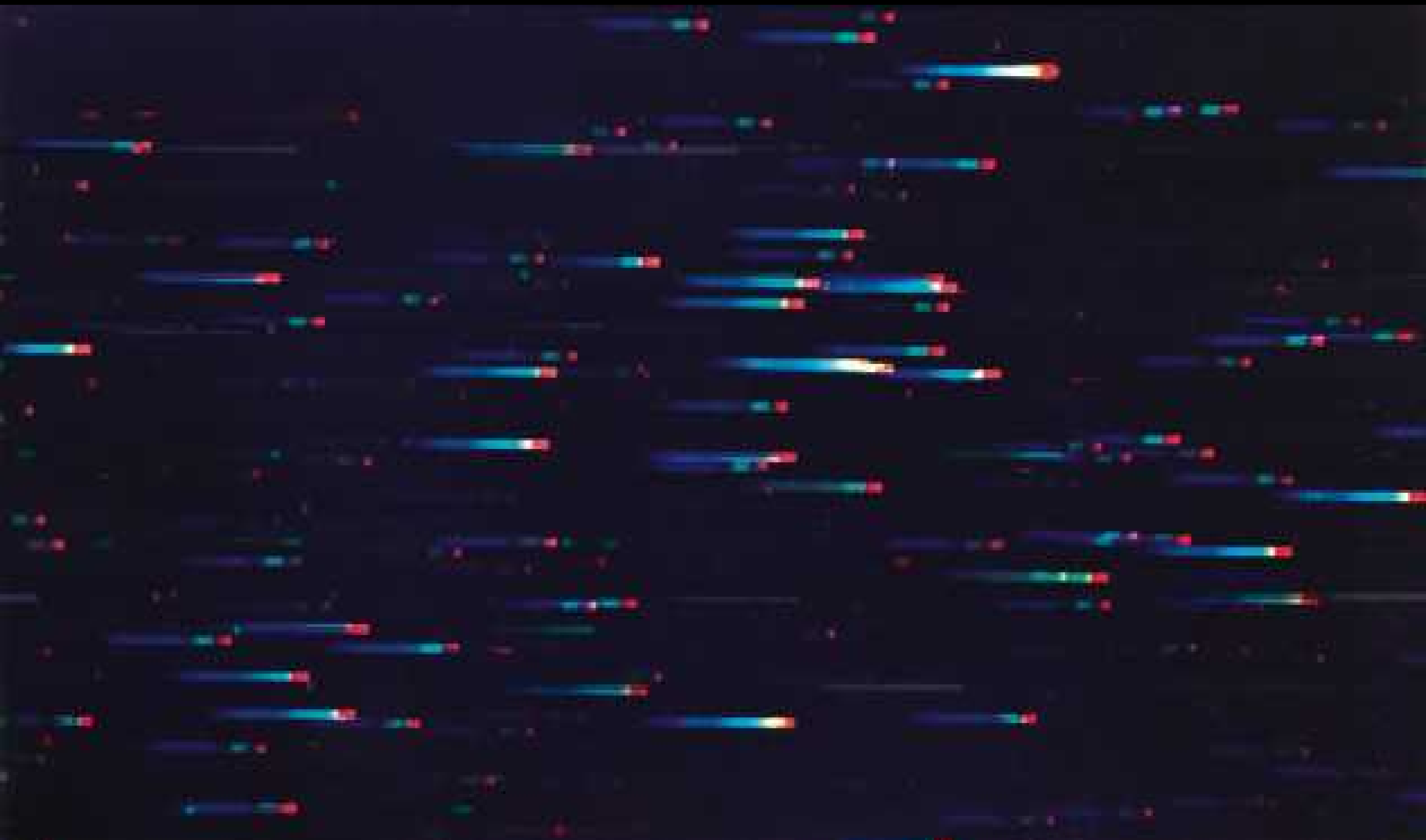


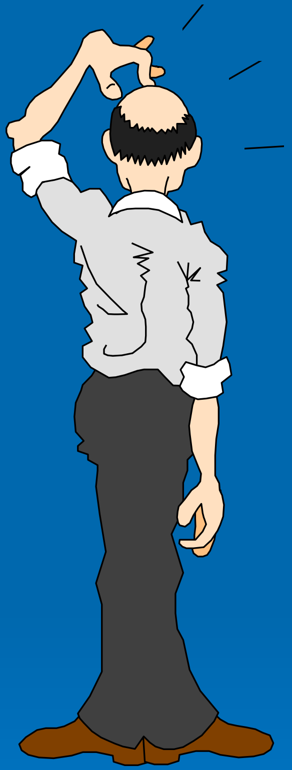
BVR Filters


3000 K
B – V = negative
6000 K
B – V ~ zero
10000 K
B – V = positive
500
1000
1500
2000
l (nm)

Photographs of Star Clusters

Spectra of Star Clusters





What do you do when you don't understand the data?

CLASSIFY!

Wide Field Spectra

But, who is going to classify all this data?

Women at Harvard

- Much of the work in classifying and explaining stellar spectra was done by women at Harvard around 1890.

Women Computers (1890)

Henrietta Leavitt (1868-1921)

Classification Scheme

A

B

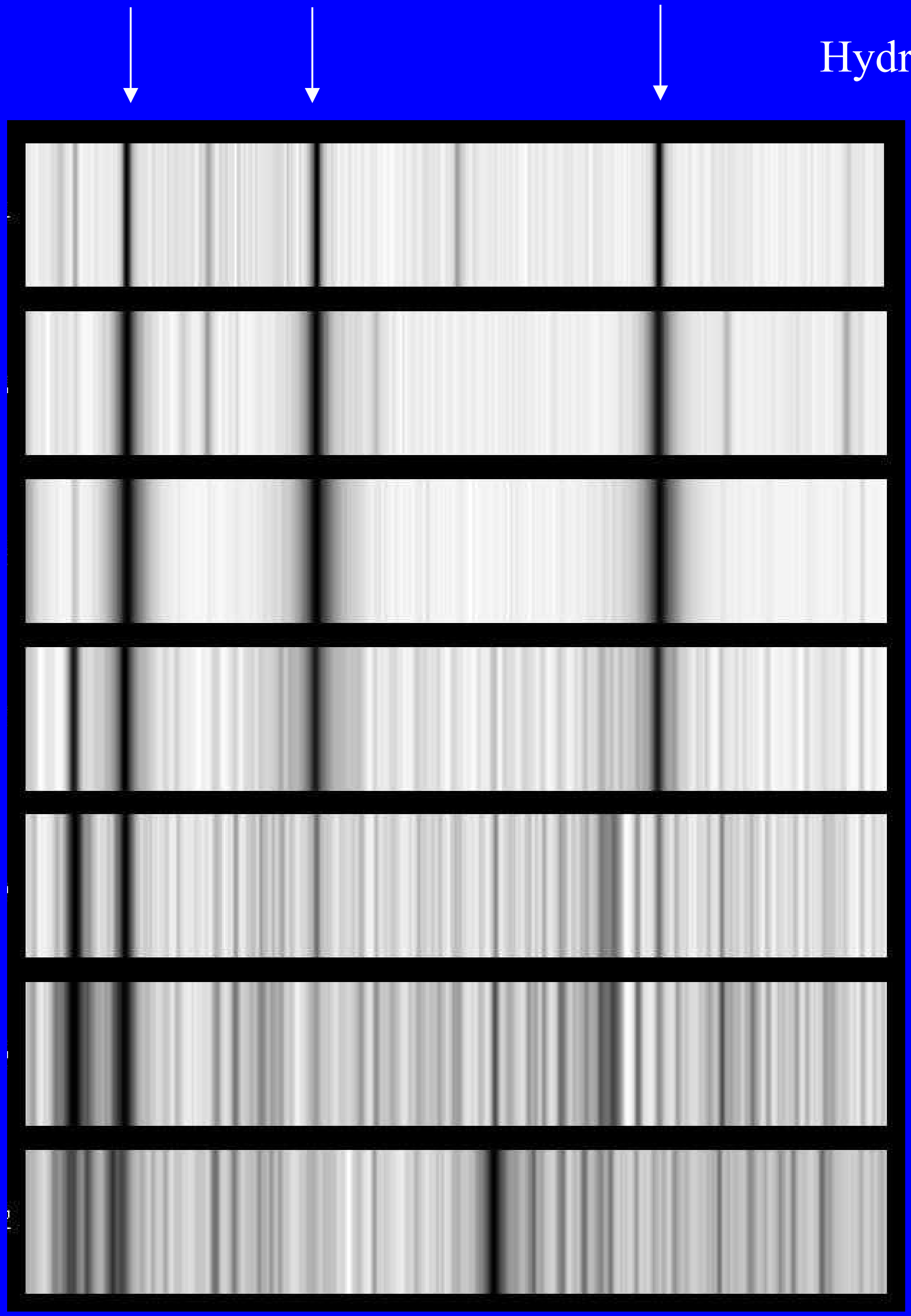
C

D

E

Fleming's system based on the strength of the Hydrogen lines in the spectrum

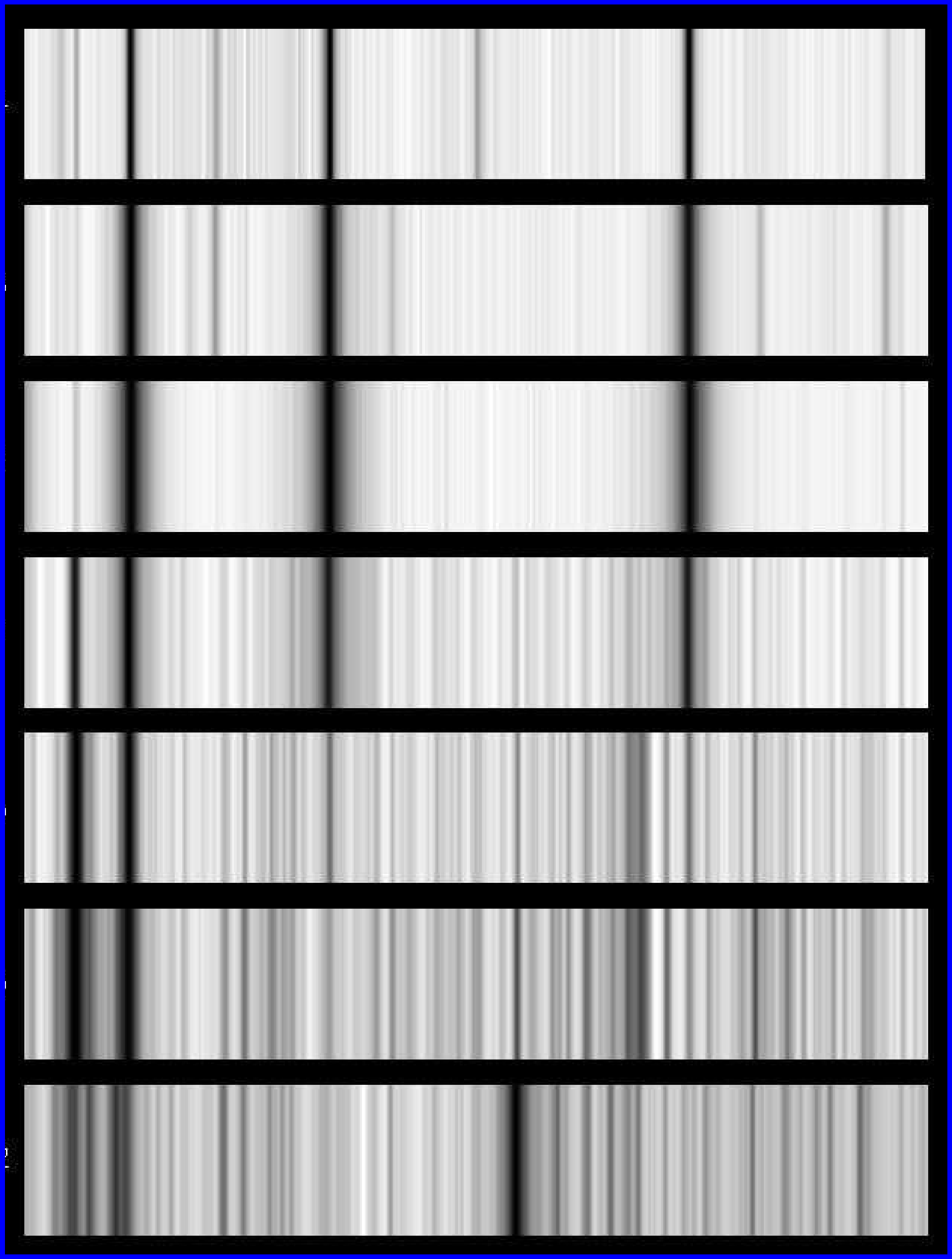
Hydrogen Lines



Annie Jump Cannon (1863-1941)

Annie Jump Cannon:

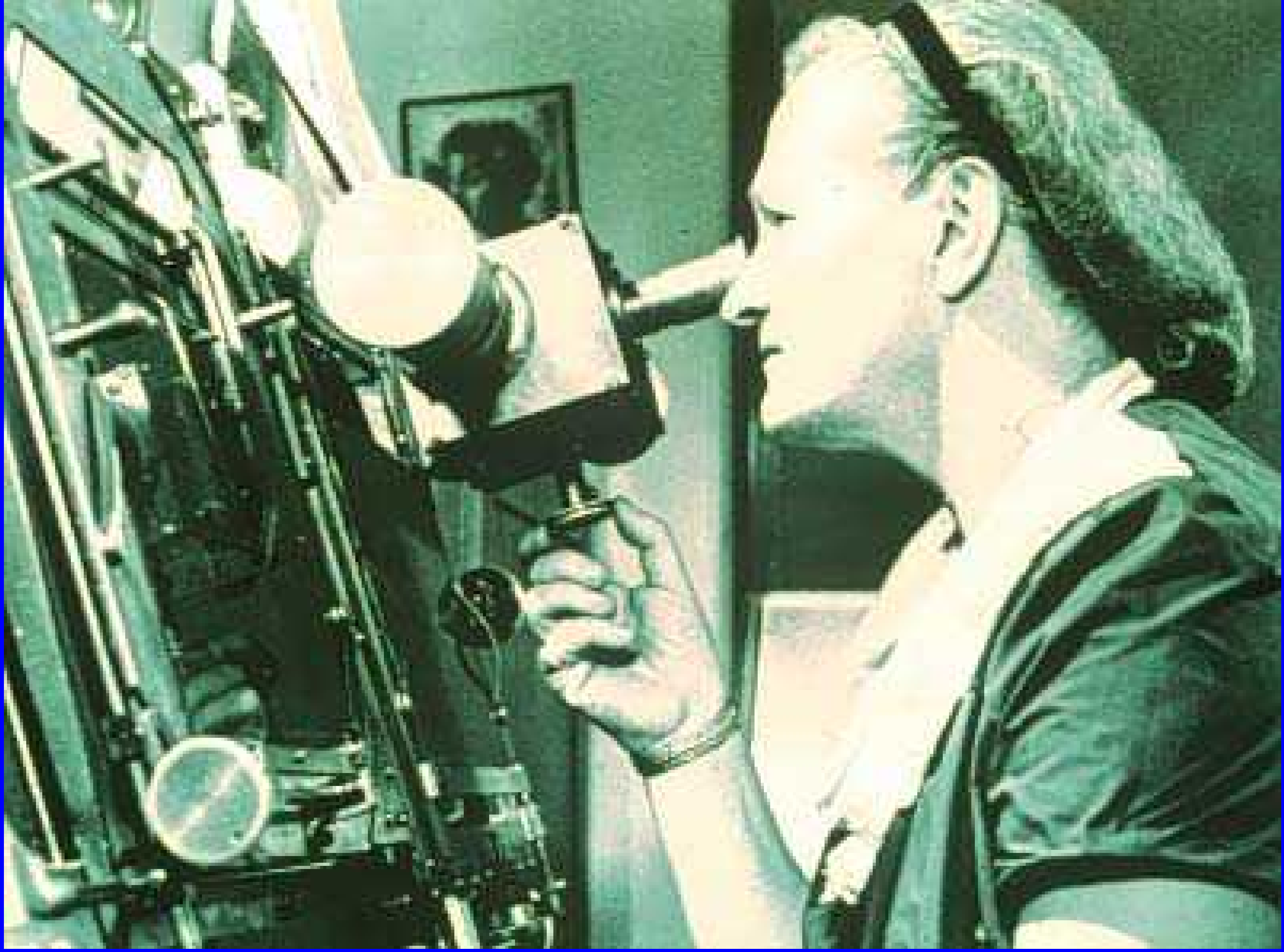
- Single-handedly classified more than 250,000 stellar spectra.
- Confirmed work of Antonia Maury that classes made more sense if arranged by temperature



Temperature

BUT WHY?

- Most astronomers believed that the differences were due to subtle differences in chemical abundance.
- Indian physicist Meghnad Saha offered another explanation, which was confirmed at Harvard.



Cecelia Payne-Gaposchkin (1900-1979)

Cecelia Payne-Gaposchkin

- Gave theoretical explanation for Cannon's classification scheme.
- Argued that differences in spectra (absorption lines) are due to temperature not abundance (*Saha Equation*)
- Differences in temperature create differences in the observed absorption spectra.
- Also, she provided the convincing argument that stars are mostly made of hydrogen.

What does this give us?

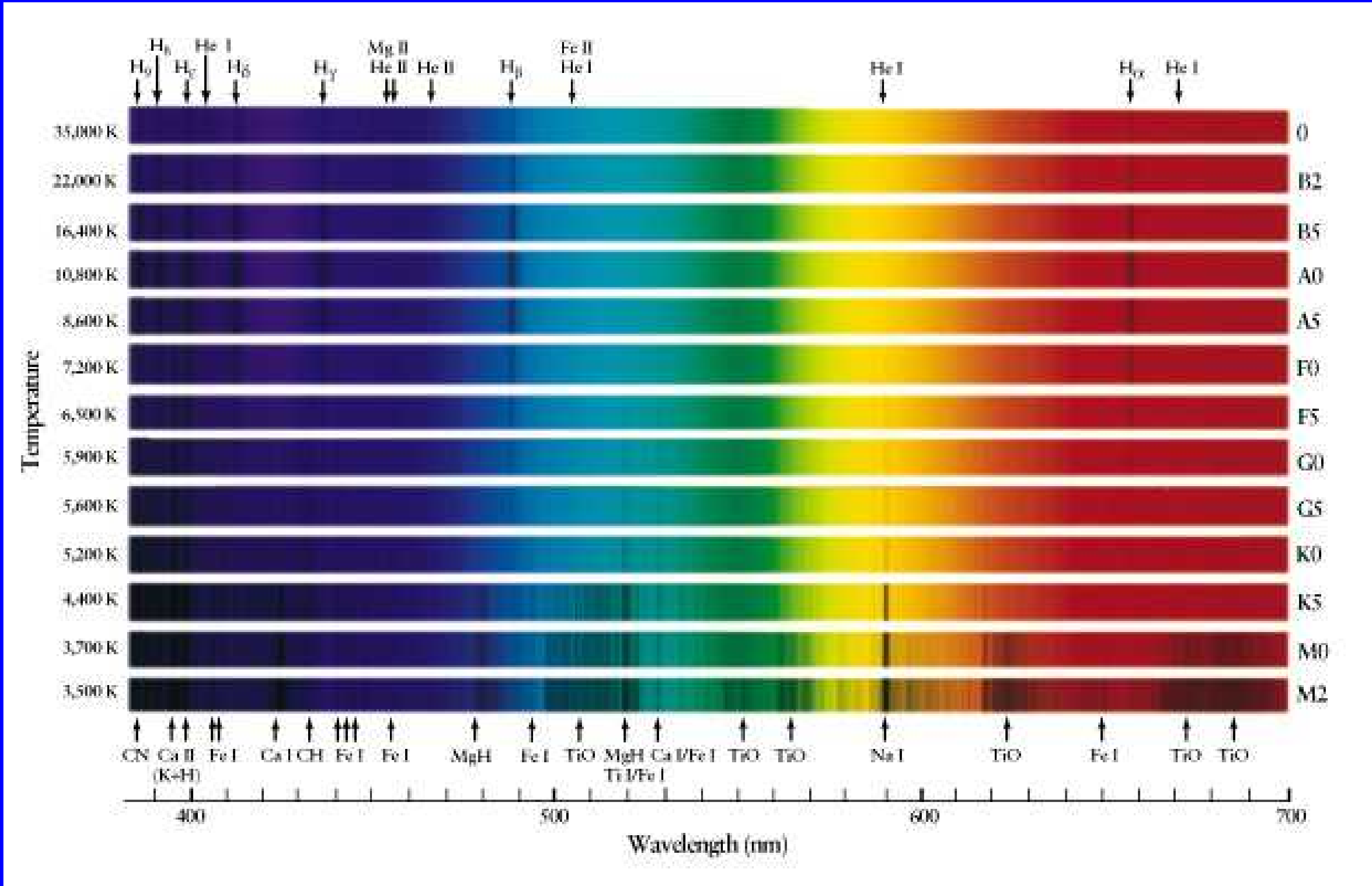
- **a new way to measure temperature**
- **can speak of color, spectral class or temperature**

(*we needed both spectral class and temperature for many stars to establish this connection*)

Summary of Spectral Classes

O	hotter than 25,000 K
B	11,000 - 25,000 K
A	7500 - 11,000 K
F	6000 - 7500 K
G	5000 - 6000 K
K	3500 - 5000 K
M	cooler than 3500 K

Stars are classified by their spectra as O, B, A, F, G, K, and M spectral types



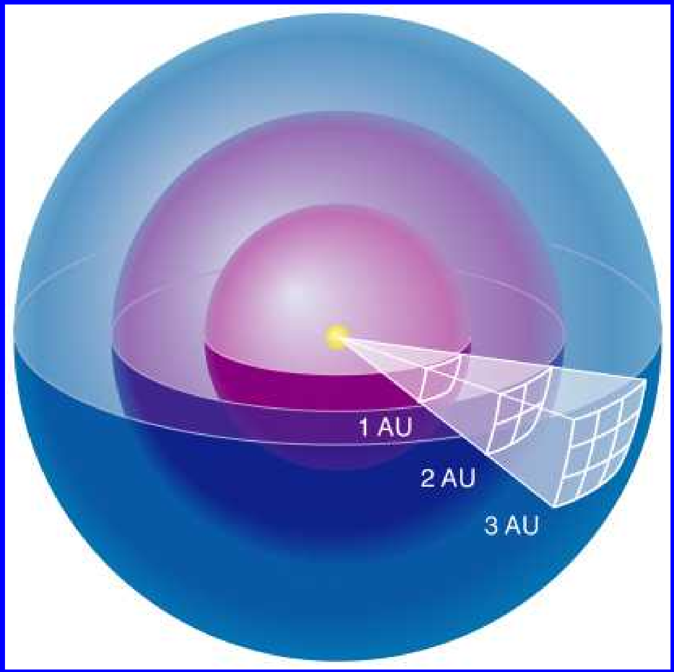
Stars are classified by their spectra as O, B, A, F, G, K, and M spectral types

- O B A F G K M
- hottest to coolest
- bluish to reddish
- An important sequence to remember:
  - Our Best Astronomers Feel Good Knowing More
  - Oh Boy, An F Grade Kills Me
  - Oh Be a Fine Guy (or Girl), Kiss Me

Luminosity of Stars

Luminosity – the total amount of power radiated by a star into space.

- **Apparent brightness** refers to the amount of a star's light which reaches us *per unit area*.
  - the farther away a star is, the fainter it appears to us
  - how much fainter it gets obeys an *inverse square law*
  - its apparent brightness decreases as the (distance)2

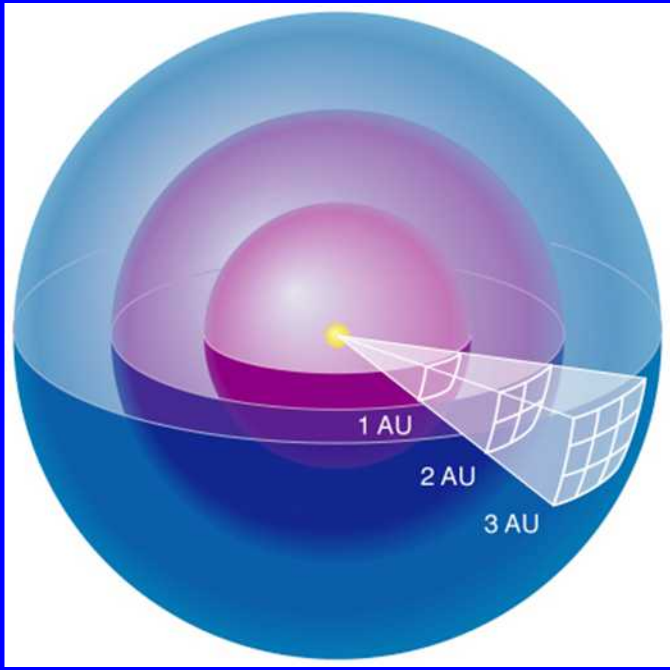


$$f \; \alpha 1 / d2$$

- The apparent brightness (flux of radiant energy (f)) of a star depends on two things:
  - How much light is it emitting: luminosity (L) [Watts = Joules/sec]
  - How far away is it: distance (d) [meters]

$$f \; \alpha L / d2$$

$$f = L / area$$

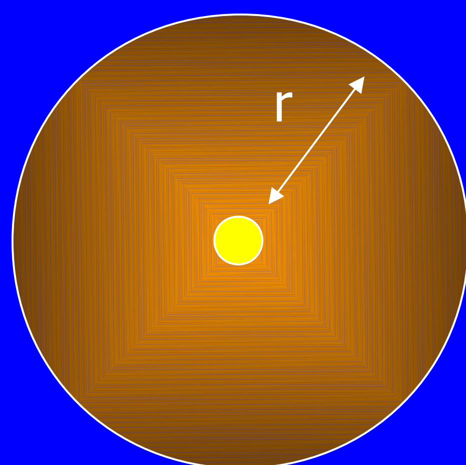


Luminosity of the Sun, L = 3.9x1026 Watts

Flux of radiant energy from the Sun =
luminosity / area = f

$$f = L / 4\pi r2$$

$4\pi r2$



(Units are W/m2)