Stars Part One:

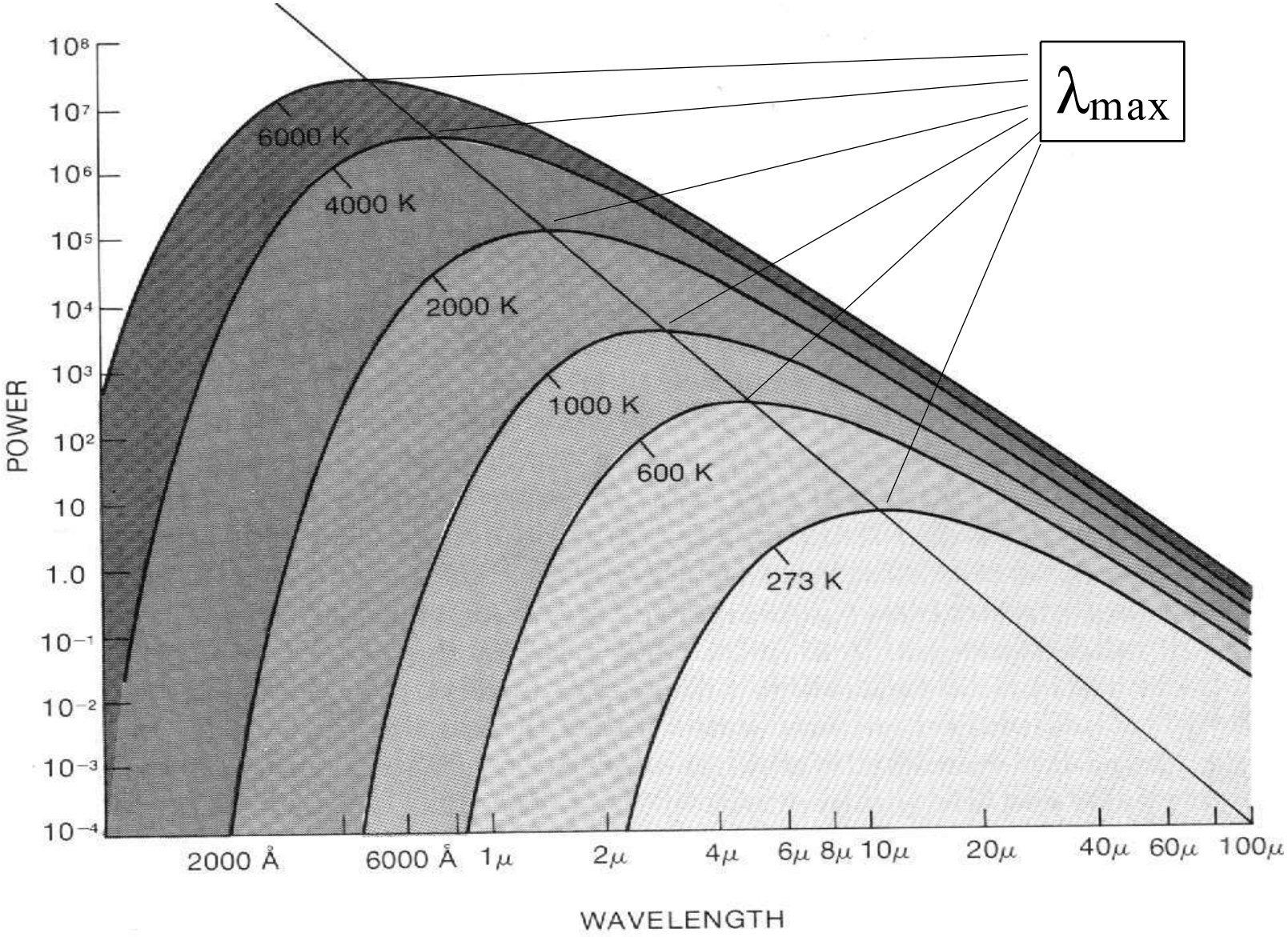
Brightness and Distance

Concept -1 – Temperature

By Measuring something called “Peak Blackbody Radiation” astronomers can calculate the temperature of a star’s surface.

This is called Wien’s Law

$$\lambda_{max} = 2.90 \times 10^{-3\ m/K}/T$$



From Jay Pasachoff's Contemporary Astronomy

Concept 0 – Total power output

Luminosity $L = \sigma A T^4$

Luminosity L = The star's power output in Watts
σ = Stefan Boltzmann constant
A = The star's surface area = $4\pi r^2$
T = The star's surface temperature in Kelvins

Concept 0 – Total power output

Luminosity $L = \sigma A T^4$

Luminosity L = The star's power output in Watts
A = Area: Bigger is brighter
T = Temperature: Hotter is brighter and bluer

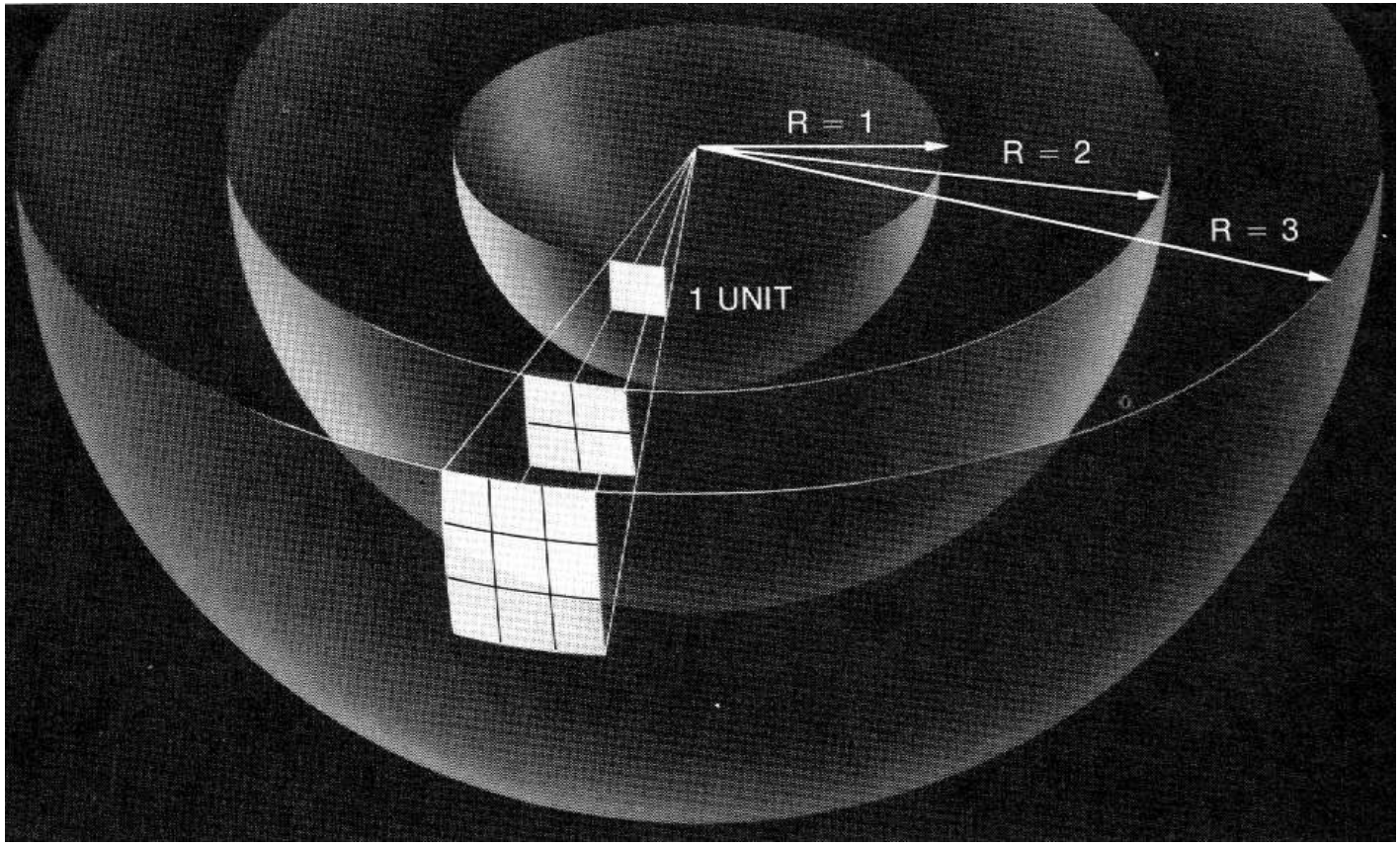
Concept 1 – Inverse Square law

Apparent Brightness $b = L/4\pi d^2$

b = The apparent brightness in W/m^2
L = The star's Luminosity (in Watts)
d = The distance to the star

The farther the star is away, the dimmer the light from it is

The idea here is that the total power is spread out over the area of an sphere whose surface is where you are, with the center on the star.



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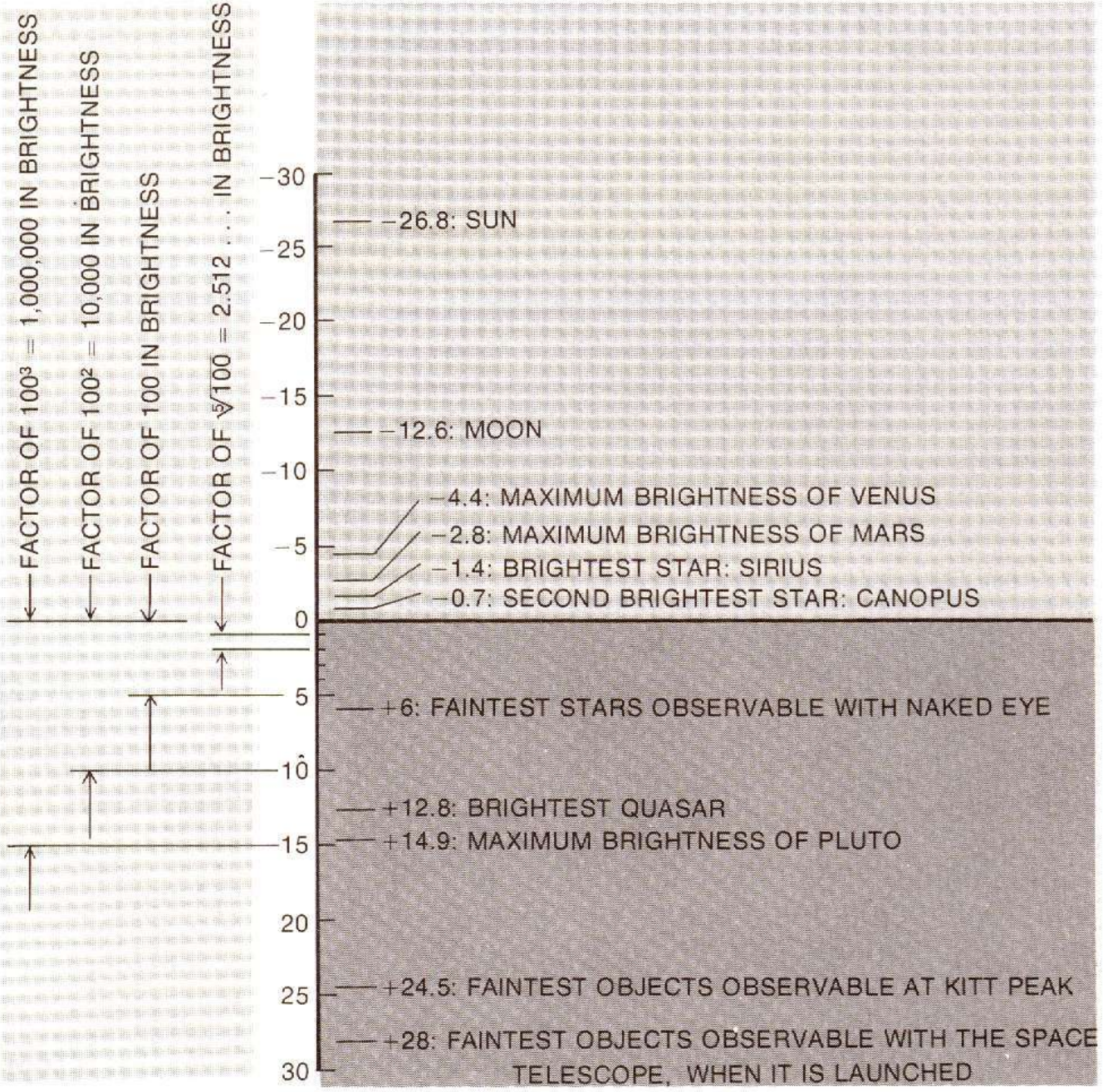
Concept 2 – Apparent Magnitude - m

The idea here is that a ratio of apparent brightness of 100, would lead to a difference in apparent magnitude of 5.

Note that the dimmer the star, the bigger m is.



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So apparent magnitude is a counter-intuitive scale

-27 is burn your eyes out,

1 is a normal bright star, and

6 is barely visible to a naked, or unclothed eye.

(You can't see anything if you clothe your eyes!!)

Remember if you go down by a factor of 5, you go up in brightness by a factor of 100. A magnitude 1 star delivers 100 times more W/m^2 than a magnitude 6 star.

Concept 3 – Absolute Magnitude - M

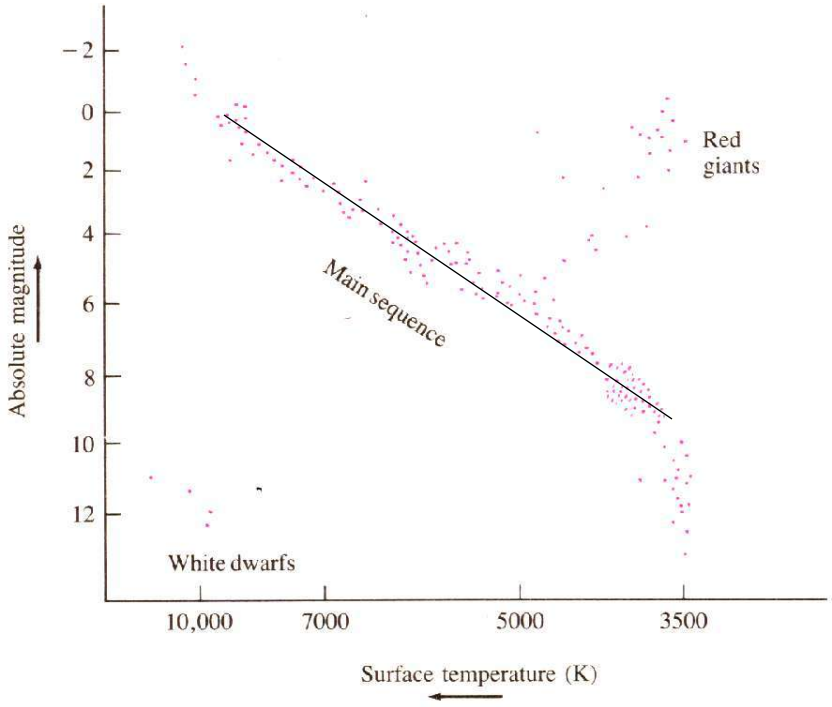
The “actual” brightness

The absolute magnitude of a star is defined as what its apparent magnitude would be if you were 10 parsecs from it.

SO…

- Temperature: Hot is bright
- Size: Big is bright
- Distance: Far is dim
- Apparent magnitude: A combination of size, temperature, and distance. -1 is bright, 6 is dim
- Absolute magnitude: Apparent magnitude at a distance of 10 parsecs. Factor of only size and temperature

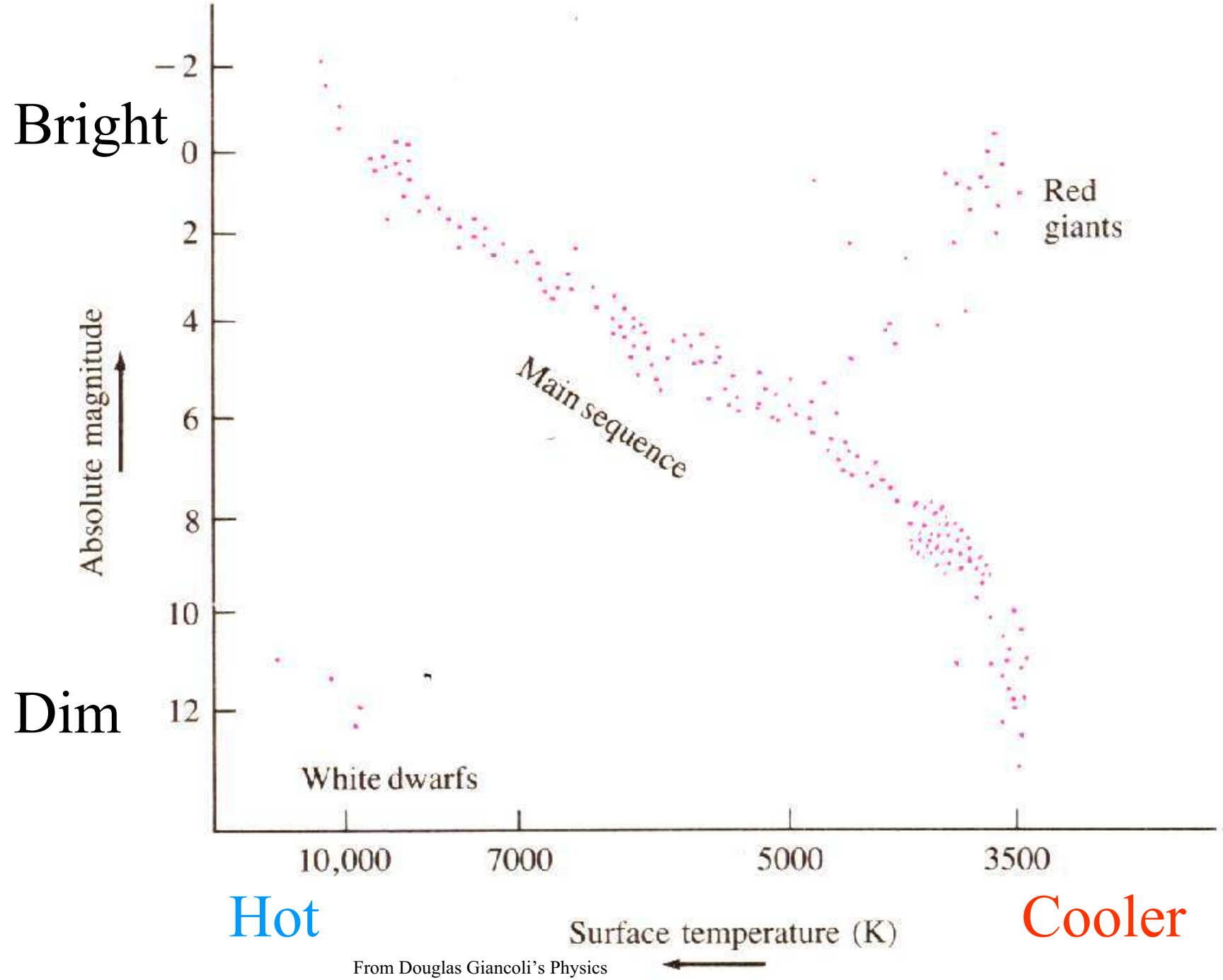
Concept 4 – H-R diagrams



In 1910, Enjar Hertzsprung of Denmark, and Henry Norris Russell at Princeton plotted M vs T in independent research.

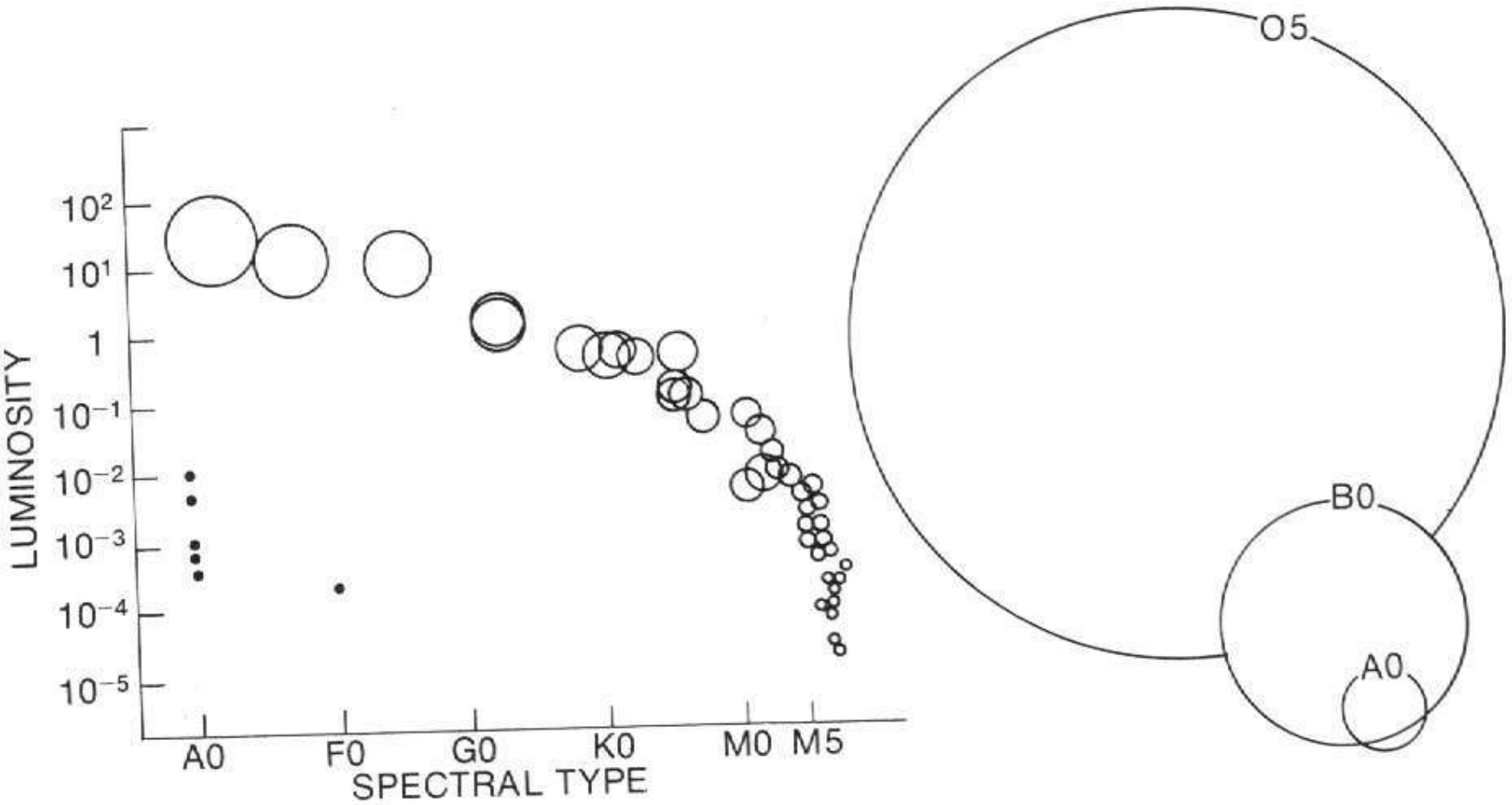
Most stars fell on a diagonal band, called the main sequence. Our sun falls on the main sequence. New and old stars are off the main sequence.

From Douglas Giancoli's Physics



From Douglas Giancoli's Physics

Bright main sequence stars are also big:



SO…

Hot stars are:

Big, **B**right, **B**rief and **B**lue

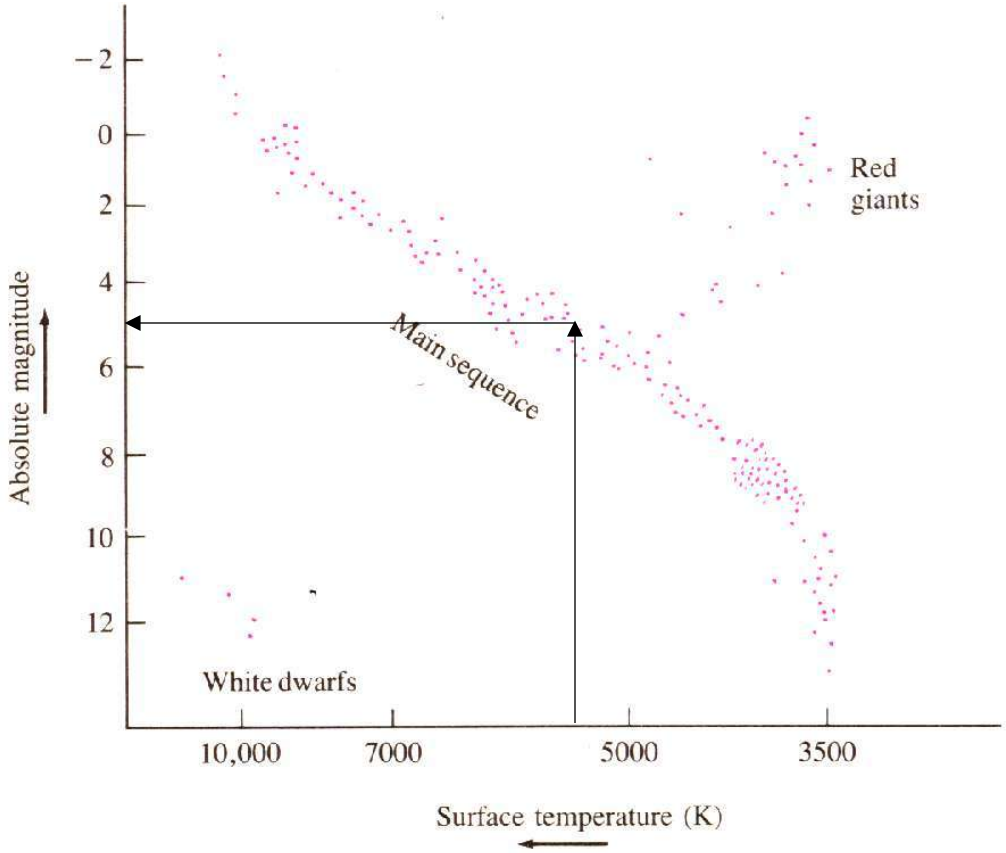
Cool stars are:

Diminuitive, **D**im, and **D**urable and um… re**D**

More about brief and durable next time…

Concept 5 - If you know how bright a star really is (Absolute magnitude), and how bright it appears (Apparent magnitude), it is pretty simple to calculate the distance to the star.

Spectroscopic "parallax"



Since astronomers can tell by the spectrum of a star if and where it falls on the main sequence, they can get the absolute magnitude. If you then measure the apparent magnitude, it is a relatively simple process to calculate the distance to the star: $M = m - 5 \log_{10}(d/10)$

And you know M, and m…

From Douglas Giancoli's Physics