HR DIAGRAM AND STAR SIZES!

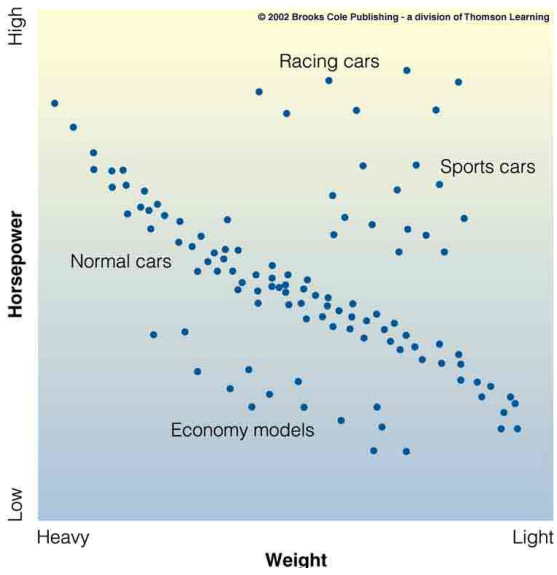
So, we know how to measure the following properties of stars…

1. **Luminosity** (from Brightness and Distance)
2. **Mass** (from Doppler shifts in Binary Stars)
3. **Temperature** (from stellar spectrum- Blackbody curve)

NOW, we will learn how to measure the sizes of stars from their luminosity and temperature!

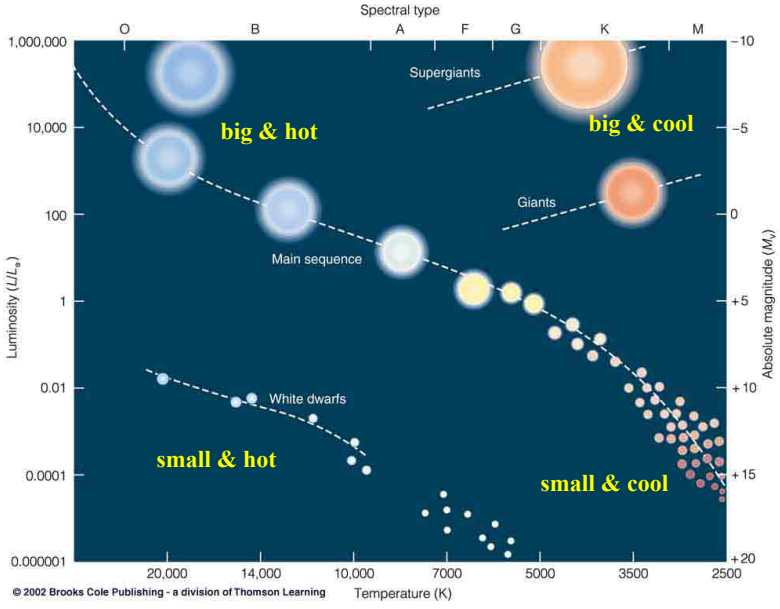
But first, the HR Diagram

HR Diagram for Automobiles



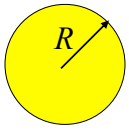
HR Diagram for Stars

Units Of Sun's



For a given star, the ***Luminosity depends upon two properties***:

1. The total surface area, that emits the light
2. The light emitted per unit surface area (flux)



Surface area is *radius dependent* Area = const x R^2

Flux is the light energy radiated from every unit area of the star's surface, it is *temperature dependent* *Flux* = const x T^4

Luminosity = k x Area x Flux

We have

$$L = k R^2 T^4$$

k is a constant

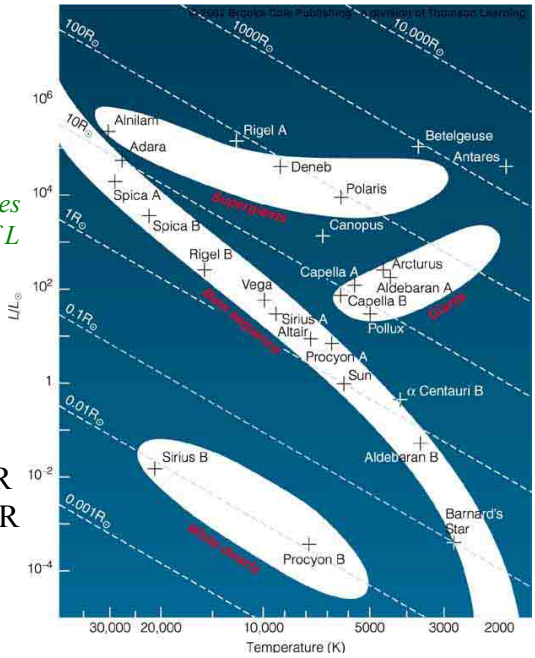
$$L = k R^2 T^4$$

The above relation is shown as lines of constant radius as a function of L and T on the HR diagram…

Main sequence:
- O Stars 10x Sun's R
- M stars 1/10x Sun's R

Giants 1000-10,000x Sun's R
White Dwarfs 1/100x Sun's R

WDs about size of Earth!



$$L = k R^2 T^4$$

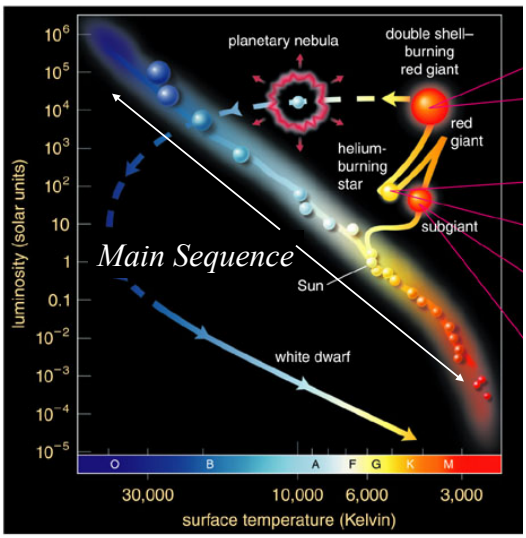
Compared to the Sun….

2 x R gives 4x L
3 x R gives 9x L
5 x R gives 25x L
½ x R gives ¼ x L

2 x T gives 16x L
3 x T gives 81x L
½ x T gives $^1/_{16}$ x L

2 x R and 2 x T gives 64 x L
3 x R and ½ x T gives $^9/_{16}$ x L = 0.56L
½ x R and 3 x T gives $^{81}/_4$ X L = 20.25L

And, so it goes…



2nd stage red giant

1st stage red giant

Let's Focus:

THE MAIN SEQUENCE

Main Sequence
Is

O, B, A, F, G, K, M

increasing temperature ⟷ decreasing temperature

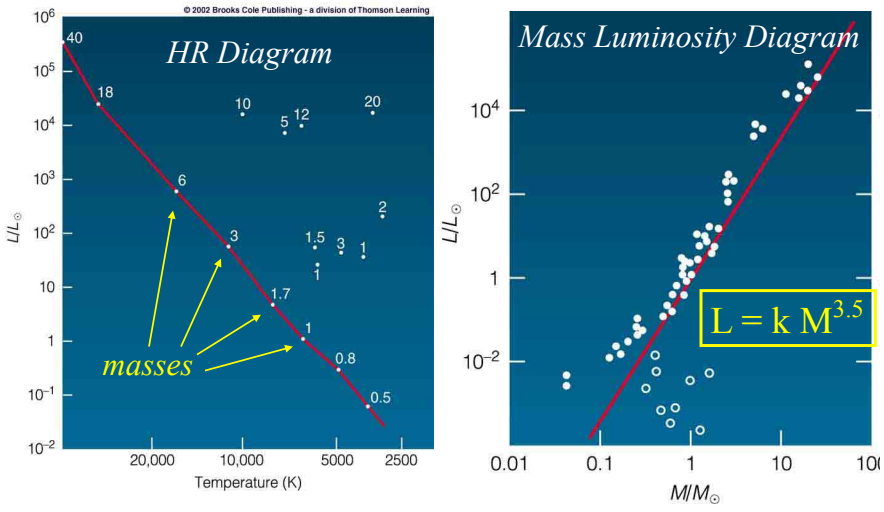
increasing size ⟷ decreasing size

increasing luminosity ⟷ decreasing luminosity

The above applies to the Main Sequence Only
Giants and White Dwarfs do NOT obey all these trends.

Main Sequence is also a Mass Sequence

As temperature increases, mass increases! As mass increases, luminosity increases!



$$L = k\ M^{3.5}$$

Compared to the Sun….

2 x M	gives	2 x 2 x 2 x sqrt(2) =	11.3 L
3 x M	gives	3 x 3 x 3 x sqrt(3) =	46.7 L
5 x M	gives	5 x 5 x 5 x sqrt(5) =	279 L
10 x M	gives	… =	3162 L
50 x M	gives	… =	883,900 L

In other words, massive stars have very very very very large luminosities

Main Sequence
Is

O, B, A, F, G, K, M

increasing temperature ⟷ decreasing temperature

increasing size ⟷ decreasing size

increasing mass ⟷ decreasing mass

increasing luminosity ⟷ decreasing luminosity

This applies to the Main Sequence Only
Giants and White Dwarfs do NOT obey all these trends.