BRIEF

HR DIAGRAM
The Main Sequence

Overview

The HR Diagram is used to provide a categorization of stars based upon their temperature and luminosity.

When plotted, very distinct regions become apparent.

In the series on the HR Diagram, this video will focus on the Main Sequence.

This is where stars will spend most of their life.

The definition of Main Sequence is a star fusing Hydrogen into Helium in its core. Once Helium fusion begins, the star leaves the Main Sequence.

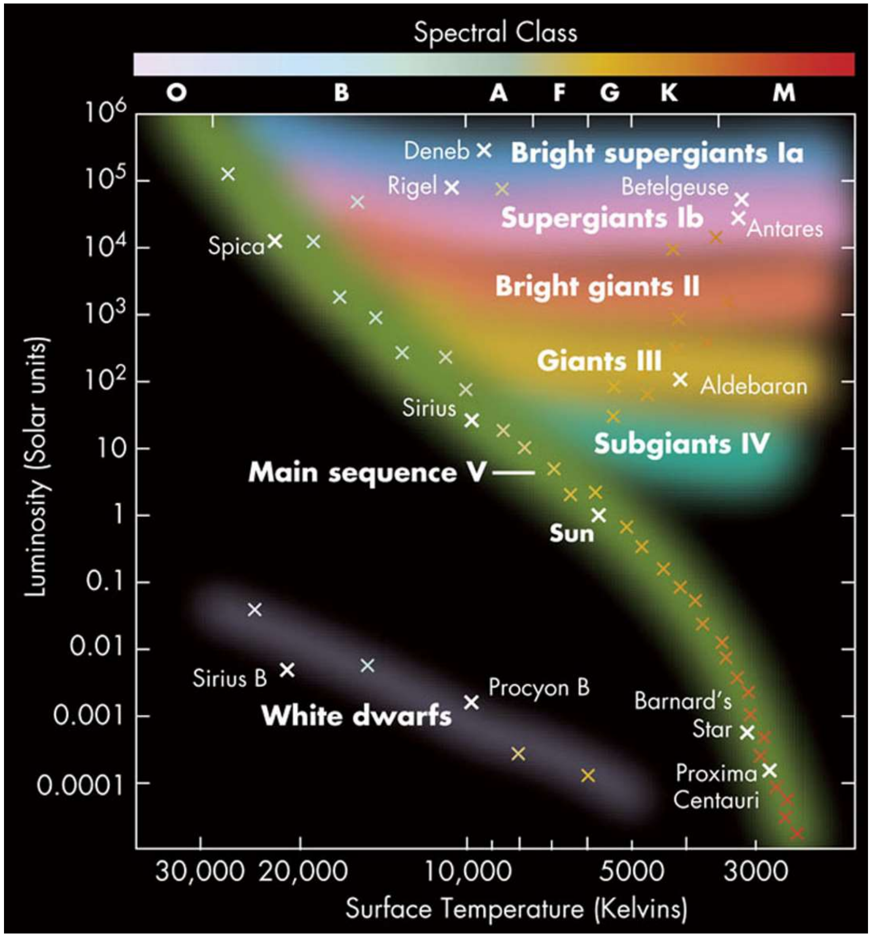
Hertzsprung-Russell Diagram Review

The *H-R diagram* is a plot of stellar temperature vs luminosity.

Most of the stars on the H-R diagram lie along a smooth diagonal running from hot, luminous stars (upper left part of diagram) to cool, dim ones (lower right part of diagram)

The diagonally running group of stars on the H-R diagram is referred to as the *Main Sequence*

Generally, 90% of a group of stars will be on the main sequence



Early and Late Stars

Early theories on stellar evolution believed that a star moved around the Main Sequence during its evolutionary cycle.

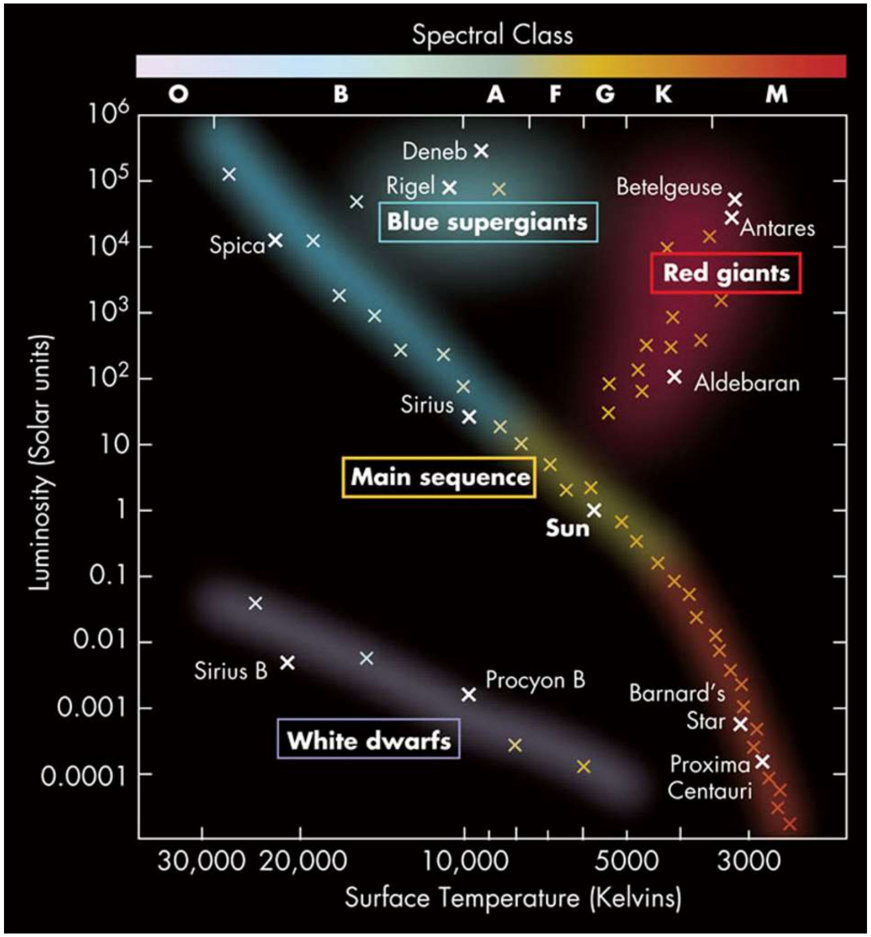
It was thought that it would start in the upper left and progress through life to the lower right.

This explained the varying color changes amongst stars.

As a result, a star considered “Early” was thought to have just begun its stellar life and thus is located in the upper left of the Main Sequence.

A star considered “Late” was considered late in its life, and therefore in the lower right of the Main Sequence.

Later research proved this concept to be untrue. HOWEVER, the Early and Late nomenclature has stuck and you will hear of some stars referred to as Early (O-Gish) and Late (K-M).

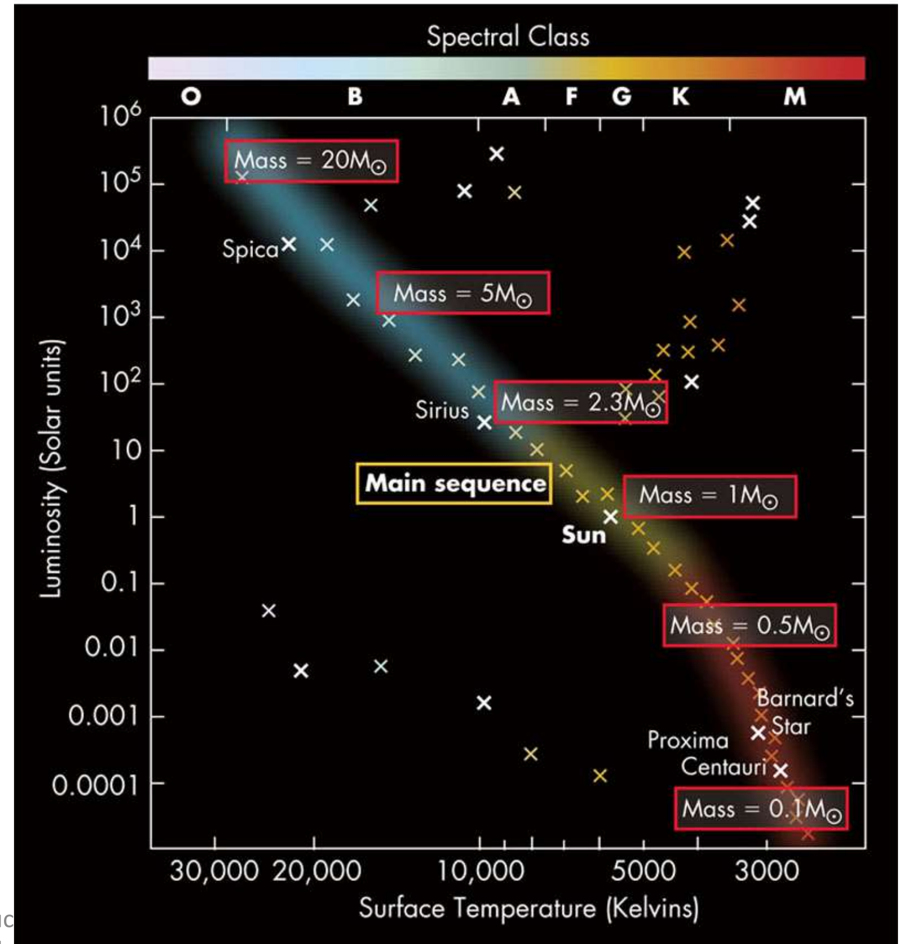


Mass and the Main Sequence

Through the study of Binary Stars, stellar mass has been determined for a number of Main Sequence stars.

The Masses are represented on this diagram in relation to 1 Solar Mass (our Sun).

As you would figure, the most massive stars are on the upper left of the HR Diagram with the least massive in the lower right.



Mass Luminosity Relationship

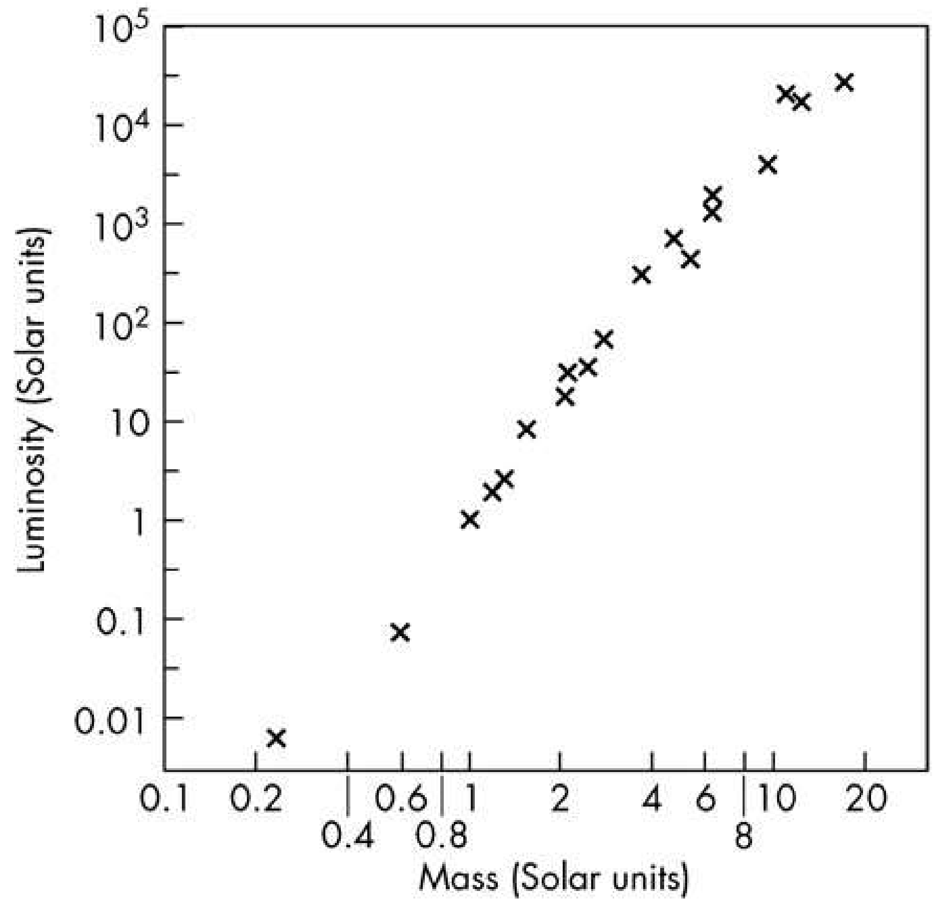
Main-sequence, ONLY MAIN SEQUENCE, stars obey a *mass-luminosity relation,* approximately given by:

$$L = M^3$$

L and *M* are measured in solar units

Consequence: If you know one value, you can determine the other. So, Mass can be determined without being in a Binary Star system.

IMPORTANT: This is true ONLY for Main Sequence stars. Once a star leaves the Main Sequence, this relation breaks down



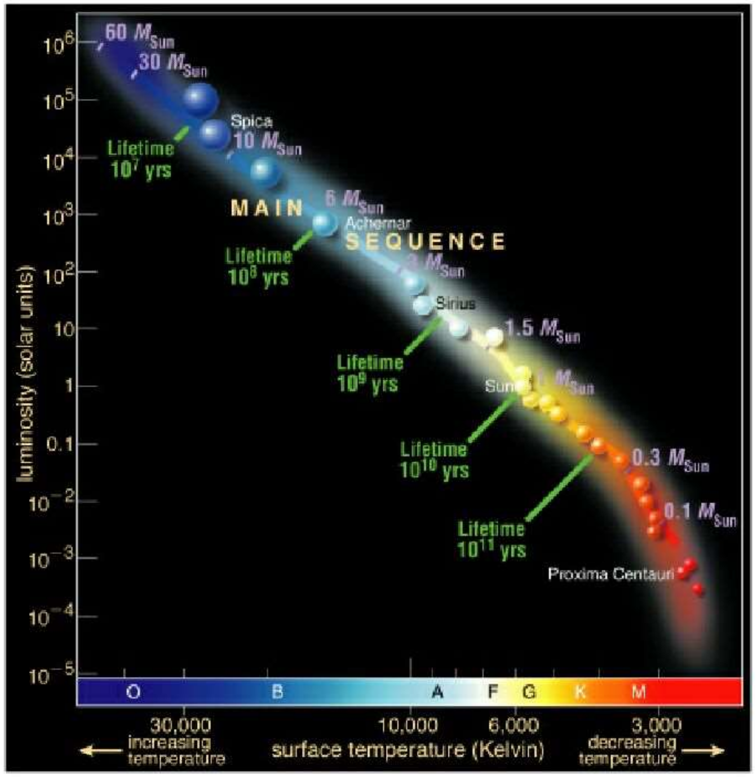
Stellar Life Times Based on Mass

Mass determines the rate at which Fusion will take place.

The more massive the star, the faster the fusion rate.

Therefore, more massive O and B type stars will burn through their fuel reserve faster than cooler, less massive, K and M type stars.

Thus, Mass determines lifetime.



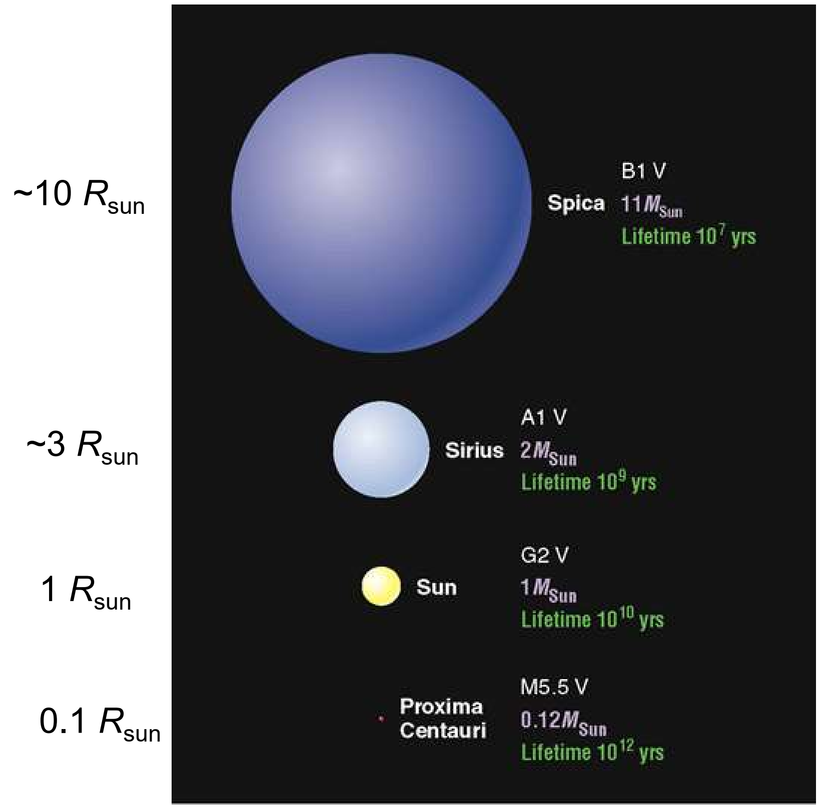
Hertzsprung-Russell Diagram: Sizes of Main Sequence Stars

The mass of the main-sequence star determine its luminosity, surface temperature, radius, and lifetime.

- Massive stars – hotter, brighter, larger, and shorter lifetime

- Light stars – cooler, dimmer, smaller, and longer lifetime.

Although the mass of Spica is 100 times that of Proxima Centauri, its lifetime is 100,000 times shorter.



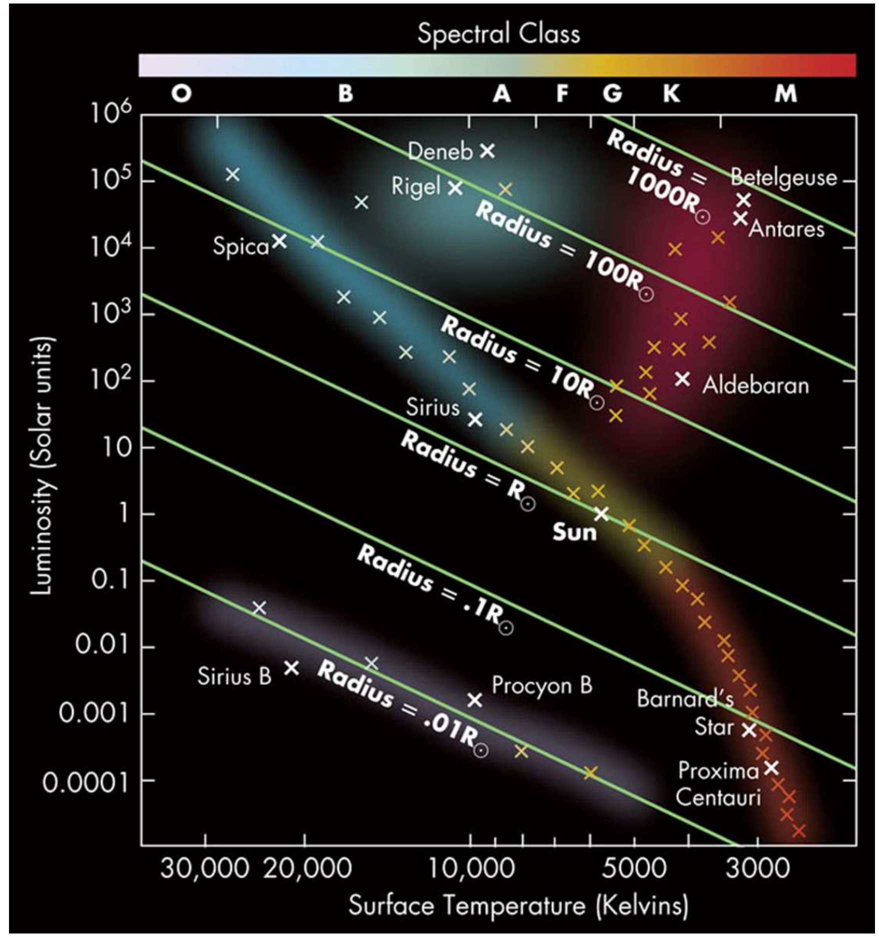
Stellar Radius

Using the radius–luminosity–temperature relationship you can find that stellar radii also vary along the main sequence…. $L = 4\pi\sigma R^2 T^4$

luminosity ∝ $radius^2 \; x \; temperature^4$

Faint, red M-type stars at the bottom right are only about one-tenth the size of the Sun, whereas the bright, blue O-type stars in the upper left are about 10 times larger than the Sun.

The diagonal dashed represent constant stellar radii, meaning that any star lying on a given line has the same radius, regardless of its luminosity or temperature.



Summary

Many stellar details can be determined by a star’s location on the Main Sequence.

Once arrived on the Main Sequence, a star is considered at ZMAS: Zero Age Main Sequence.

It will stay in its position until Hydrogen fusion gives way to Helium.

Its position on the Main Sequence is determined by Mass. From this position we can also determine: Luminosity, Temperature, Radius, and Stellar Lifetime.

After the Main Sequence, a star will begin its “death” process by a path dictated by its Mass.

Questions?