11.8: Star and Celestial Object Characteristics

Star characteristics consider physical characteristics such as **stellar mass, size, surface temperature, and luminosity**. These basic characteristics assist in detailing specifics about a star; not all stars are the same and these variations in characteristics can be significant. The distance from the Sun and Earth to a specific star is also important as astronomers detail the star's characteristics. Of these characteristics, **stellar mass** is the most important characteristic. The mass of a star determines things, such as how quickly a star will consume its stellar fuel through the fusion process to the star's final ending when it has used all of its fuel. Yet how does one measure a star's mass? How do you weigh a star?

It turns out that Isaac Newton studied this question. He turned to Kepler's Third Law, where one measures the **period** and **average distance** of the object's orbit about a star. Yet, you need two objects – a star and an object orbiting a star – to use this solution. It turns out that over 50% of all stars have a companion star. So, astronomers use this adaptation on Kepler's Third Law developed by Newton to measure the mass of the two binary stars.

Kepler's 3rd Law — $a^3 = kP^2$

Where **a** is the orbiting object's semi major axis, **P** is the orbiting object's period to orbit, and **k** is a constant, referred to as Kepler's constant.

By examining the color of each of the stars in the binary system, you can compare two single stars with the same colors.

Stellar mass is usually related to the mass of the Sun, where the Sun equals 1 m_{sun}, 1 $m_{\odot}$, or 1 solar mass. The bright star Sirius, the Dog Star in the constellation Canis Major, is about 2. 02 m_{sun}. One of the most massive stars is Eta Carinae, with a mass somewhere between 100 to 150 times the mass of the Sun, 100-150 $m_{\odot}$.

Stellar mass units — m_{sun} :: $m_{\odot}$ :: solar mass

A star's mass will vary over its lifetime, depending if it adds, or accretes, mass from another star, loses mass to another star, or simply loses mass through the normal processes, such as through its stellar wind or pulsating outputs.

Stars are occasionally classed by their stellar masses based upon their evolutionary behavior as stars approach the end of their nuclear fusion. In the next module, we will introduce the classes of stars, based on their solar masses.

Stellar size refers to a star's diameter or radius. Stars range in diameter, from neutron stars with diameters of about 40 kilometers or 25 miles, to supergiants with diameters of approximately 900,000,000 kilometers or 540,000,000 miles — about 650 times the Sun's diameter.

A star's **surface temperature**, measured in Kelvin, K, is dependent on the star's diameter and the rate of energy production at the stellar core, and is measured at the star's photosphere. An estimate of the surface temperature is the star's **color**, often called the **color index**. Annie Jump Cannon was the first to sort spectral data and designed the stellar spectral classes.

The hotter the star, the whiter it will appear, whereas the cooler the star, the redder it will appear. Think of heating a piece of metal; the hotter it is, the whiter the metal will appear. As the metal cools, it will appear orange and then red in color. The reddish-colored metal is still hot, yet cooler than when the metal was white blue-white in color.

Stellar luminosity is the amount of light and other radiant energy released by a star. A star's luminosity is dependent on its diameter (sometimes noted as the star's radius, d = 2r) and its surface temperature.