NEWSELA

Classifying the stars: from dwarfs to supergiants

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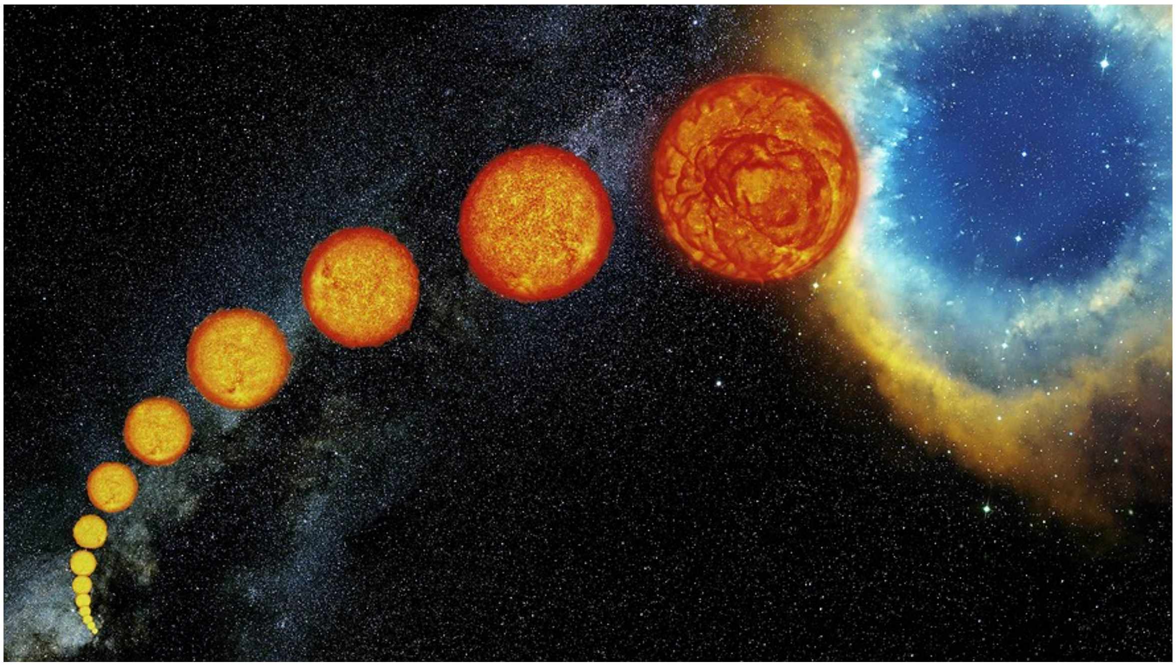


Artist's depiction of the life cycle of a sun-like star, starting as a main-sequence star at lower left, then expanding through the subgiant and giant phases until its outer envelope is expelled to form a planetary nebula at upper right. Image by: S. Steinhofel/ESO.

The classification of stars is based primarily on their temperatures. Stars that fall within a given temperature range are assigned a particular letter, and then further categorized into 10 more subclasses, each expressed by a number. For example, our sun has a temperature of about 5,700 Kelvin and is classified as a G2 star.

Kelvin is a measure of temperature used in physical sciences that differs from both Celsius or Fahrenheit. Kelvin measures the speed of motion of the particles within something, in this case, a star. The faster the particles move, the hotter the star is and the higher the Kelvin temperature.

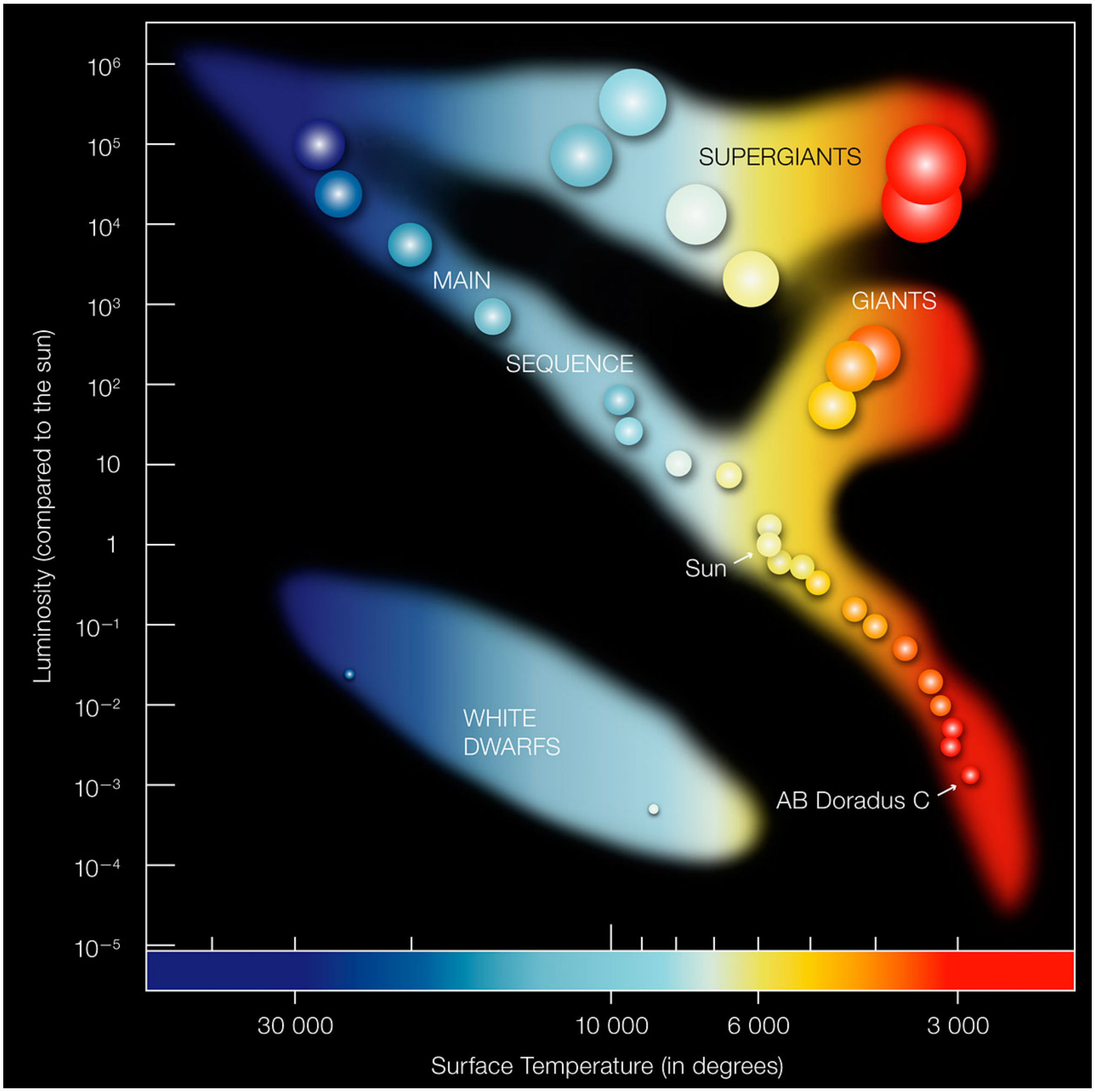
However, this classification system, which is known as the Harvard spectral classification scheme, does not completely describe a star: It cannot distinguish between stars with the same temperature but different luminosities, or degrees of brightness. In other words, it cannot distinguish between main sequence (dwarf) stars, giant stars and supergiant stars.

For this reason, the Morgan-Keenan (MK) luminosity class was established. Originally, it used only roman numerals between I (supergiant star) and V (main sequence). These days, class I stars have been subdivided into Ia-O, Ia and Ib. In addition, classes VI (sub-dwarf) and D (white dwarf) have been added.

Plotting Temperature Against Luminosity

To completely describe a star, the MK luminosity class is added to the original Harvard classification. For example, our sun is a main sequence G2 star, therefore its full classification is G2V.

The Hertzsprung-Russell diagram (HR diagram) is one of the most important tools in the study of the evolution of stars. It plots the temperature of stars against their luminosity, or the color of stars against their size.



Depending on its initial mass, every star goes through specific evolutionary stages dictated by its internal structure and how it produces energy. Each of these stages corresponds to a change in the temperature and luminosity of the star, which can be seen to move to different regions on the HR diagram as the star evolves. This reveals the true power of the HR diagram: Astronomers can know a star's internal structure and evolutionary stage simply by determining its position in the diagram.

From Hot And Luminous To Cool And Faint

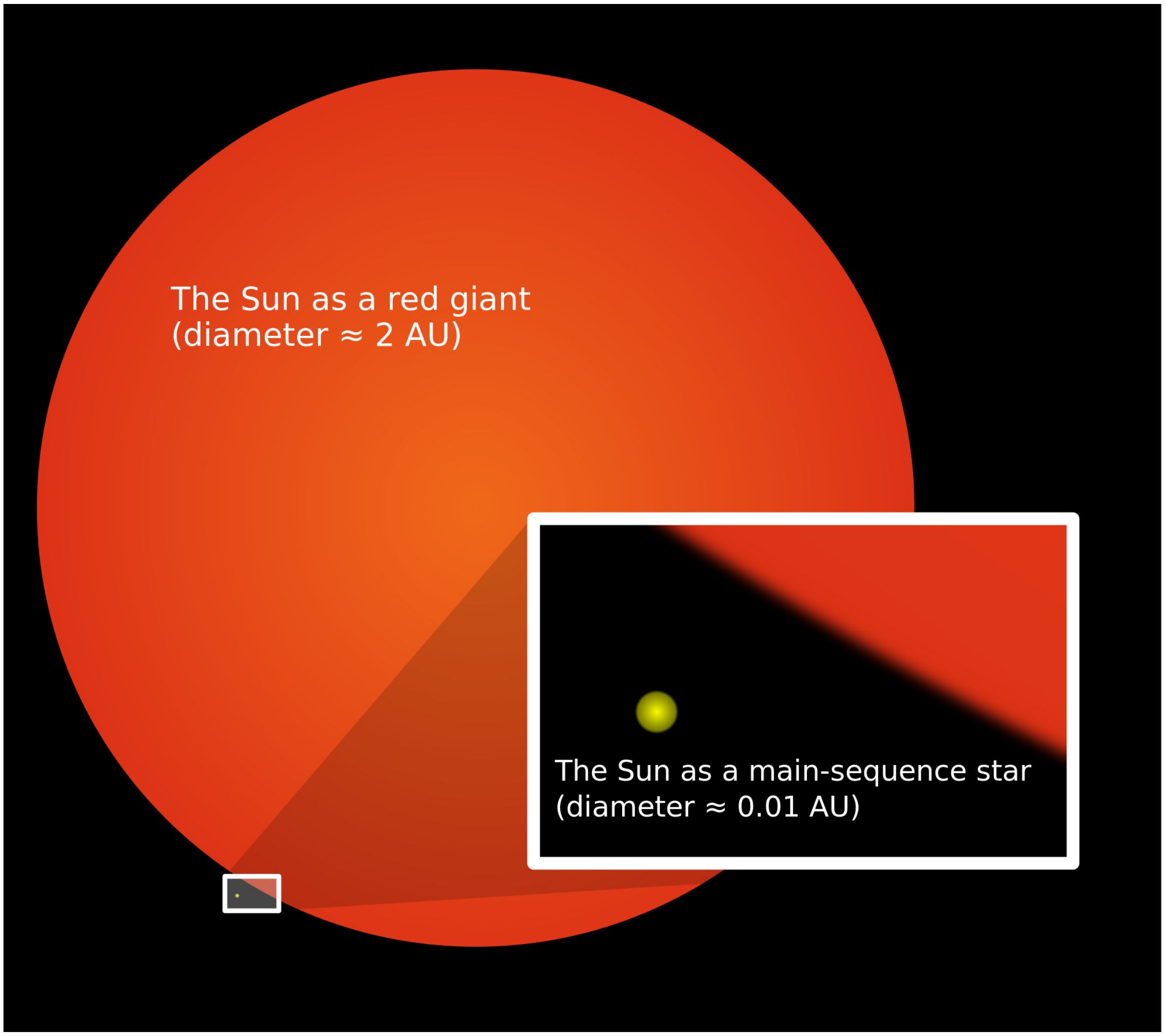
This HR diagram shows a group of stars in various stages of their evolution. By far the most prominent feature is the main sequence, which runs from the upper left (hot, luminous stars) to the bottom right (cool, faint stars) of the diagram. The giant branch is also well populated and there are many white dwarfs. Also plotted are the Morgan-Keenan luminosity classes that distinguish between stars of the same temperature but different luminosity.

There are three main regions (or evolutionary stages) of the HR diagram:

1) The main sequence dominates the HR diagram. It is here that stars spend about 90 percent of their lives burning hydrogen into helium in their cores. Main sequence stars have a Morgan-Keenan luminosity class labeled V.

2) Red giant and supergiant stars (luminosity classes I through III) occupy the region above the main sequence. They have low surface temperatures and high luminosities, which means their radius is also large. Stars enter this evolutionary stage once they have exhausted the hydrogen fuel in their cores and have started to burn helium and other heavier elements.

3) White dwarf stars (luminosity class D) are the final evolutionary stage of low to intermediate mass stars and are found in the bottom left of the HR diagram. These stars are very hot but have low luminosities due to their small size.



How Our Sun Measures Up

The sun is found on the main sequence with a luminosity of 1 and a temperature of around 5,400 Kelvin.

Astronomers generally use the HR diagram to either summarize the evolution of stars or to investigate the properties of a collection of stars. In particular, by plotting an HR diagram for a cluster of stars, astronomers can estimate the age of the cluster.

Quiz

1 Which of the following BEST represents how scientists initially classified stars?

(A) Scientists initially classified stars based on a star's luminosity.

(B) Scientists initially classified stars based on a star's size and age.

(C) Scientists initially classified stars based on a star's temperature.

(D) Scientists initially classified stars based on a star's brightness compared to the sun.

2 How does the article develop the idea that the HR diagram gives scientists a more complete understanding of stars?

(A) by explaining how the HR diagram helps scientists learn where a star is in its life cycle

(B) by stating that the HR diagram is easy for scientists to read and understand

(C) by listing the evolutionary stages scientists included in the HR diagram

(D) by proving that scientists have combined the HR diagram and the MK luminosity class

3 Read the final section "How Our Sun Measures Up."

Why does the author choose to conclude with this section?

(A) to make readers understand the main idea by classifying a well-known star and to prove that the HR diagram is best

(B) to provide an example of classification using a popular star and to summarize the HR diagram's key benefits

(C) to suggest the sun cannot be measured on the HR diagram and to list how the HR diagram can be used

(D) to answer a question posed earlier in the article and to summarize the differences between three classification schemes

4 Which paragraph in the introduction [paragraphs 1-4] represents a major shift in the article's development?