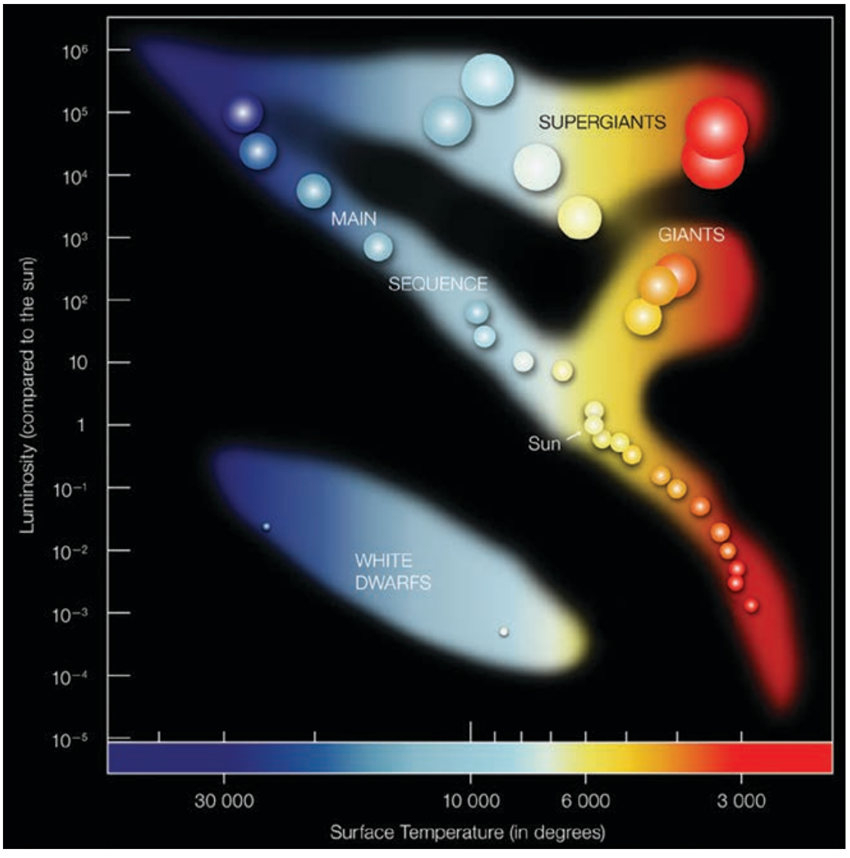
Star chart

BY BOB RIDDLE

In the early 1900s, scientists Ejnar Hertzsprung and Henry Norris Russell developed the H-R (Hertzsprung-Russell) diagram. The H-R diagram is a representation of the relationship between a star's luminosity and its temperature (see Figure 1). Astronomers use the H-R diagram to classify stars based on their spectral type and understand the evolution, size, and temperature of stars. The H-R diagram can also be used to infer distances to stars.

FIGURE 1: A simplified H-R diagram



HTTP://SPIFF.RIT.EDU/RICHMOND/ASRAS/DISTANCE_I/CLUSTERTURNOFF.SWF

Stars plotted on the H-R diagram are placed at the intersection of the star's spectral type (e.g., white dwarfs and giants) and luminosity. The H-R diagram reveals part of a star's life cycle as well as its future. As a star ages, it will move from left to the right on the diagram. (See Resources for "Cluster Turnoff" and an animation showing a star cluster changing positions on the H-R diagram.)

The vertical axis of the H-R diagram shows the luminosity while the horizontal axis displays the *spectral type*, which is based on the temperature of the star. The values on the H-R diagram are based on our Sun's luminosity, which has a value of 1. Stars with values greater than 1 are brighter than the Sun, whereas stars with lesser values are dimmer.

Most of the stars on the H-R diagram are arranged from the top left to bottom right in a diagonal pattern, known as the *main sequence*. Like the Sun, stars in the main sequence are still fusing hydrogen in their core. Stars near the top right such as giants and supergiants, are larger, brighter, and cooler. To the left of the giants and supergiants are even brighter stars. Toward the bottom right are smaller, cooler, and dimmer stars. Along the bottom left are the small white stars that are much hotter and brighter than their counterparts toward the bottom right side.

Each star also belongs to a specific luminosity class represented by a 0 or Roman numerals I through V, with two subdivisions for class I and two additional groups after class V. The luminosity classes are used to indicate a star's size. The brightest and largest stars (i.e., hypergiants and supergiants) belong to luminosity classes 0, I, Ia, and Ib; bright giant stars belong to luminosity class II; giant stars are with luminosity class III; subgiant stars are in luminosity class IV; and stars of luminosity class V are found along the main sequence. After class V are the dimmest stars such as subdwarfs (SD)and white dwarfs (D).

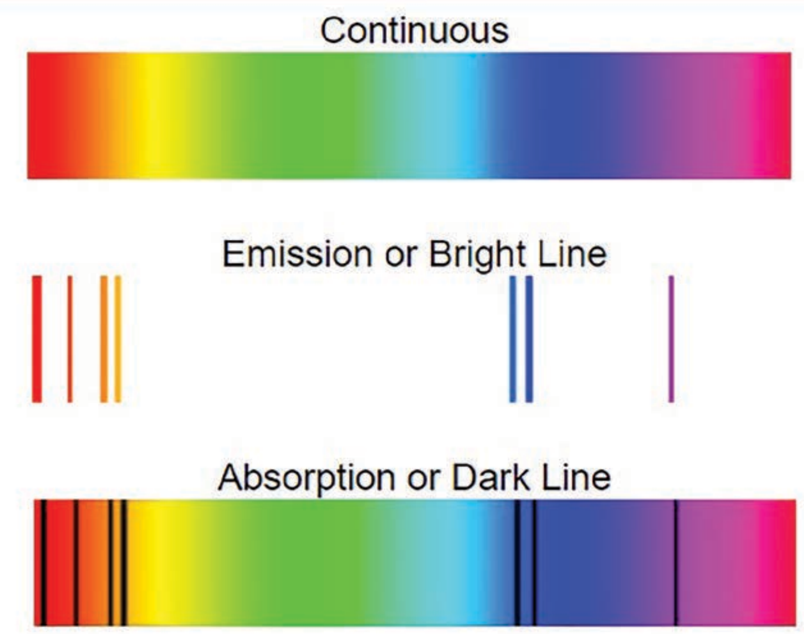
Understanding spectral types

A star's spectral type and color are based on the temperature of the star's surface and the light coming from the surface. A telescope equipped with a spectroscope receives the star's light that passes through a prism or a diffraction grating so that it can be seen in a rainbow of colors.

There are three spectral types (Figure 2). Spread along the colors are dark lines, known as *absorption* or *dark line spectra*, that help scientists understand the

FIGURE 2: The three types of stellar spectra

The location of dark lines indicates where radiation is blocked or absorbed.



HTTP://IMAGINE.GSFC.NASA.GOV/SCIENCE/TOOLBOX/SPECTRA1.HTML

December

3 Moon very near Aldebaran
Full Moon

4 Moon at perigee 357,000 km (222,140 mi.)

5 Waning gibbous Moon

7 Waning gibbous Moon near Beehive Star Cluster
Moon at ascending node

8 Moon very near Regulus

10 Last quarter Moon

12 Mercury at inferior conjunction

13 Waning crescent Moon near Mars

14 Geminid shower
Waning crescent Moon near Jupiter

18 New Moon
Moon at apogee 406,000 km (252,649 mi.)

19 Moon at Southernmost Declination: [What does "Dec" stand for?] 20.1° S

21 Winter solstice (11 a.m. EST)
Saturn at solar conjunction

22 Moon at descending node
Ursid shower

26 First quarter Moon

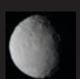
30 Waxing gibbous Moon near Aldebaran

Visible planets

Mercury will be visible in the morning skies before sunrise for the first part of the month and then will move into inferior conjunction and will reappear as an evening planet by January.

Venus will be visible over the eastern horizon early in the month before moving too close to the Sun to be visible.

Mars will start the month near the blue-white star Spica and will steadily move eastward toward a close conjunction with Jupiter at month's end.

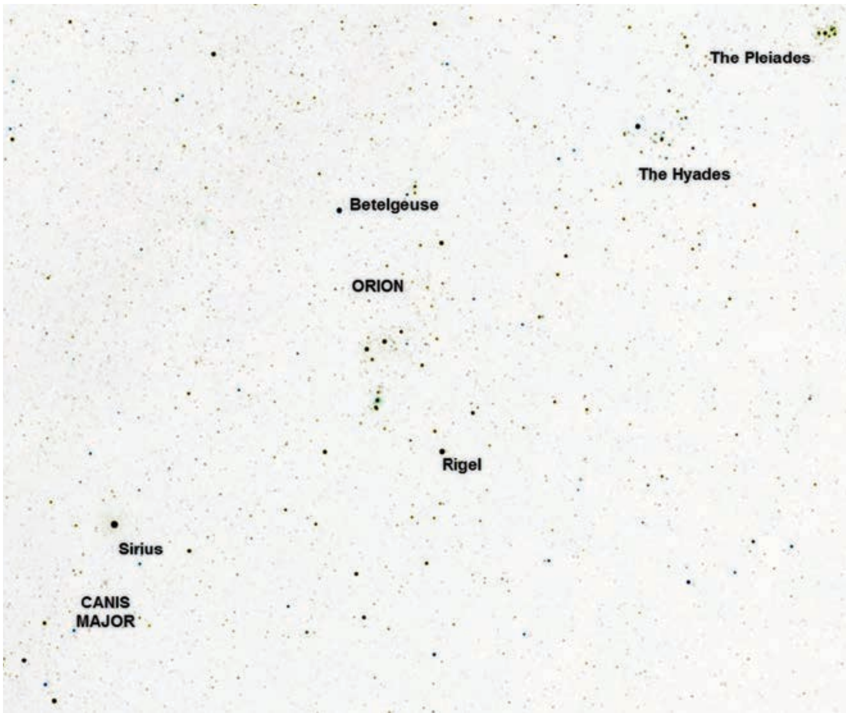


Ceres will rise around midnight local time and will be over the southern horizon at sunrise.

Jupiter will be very visible over the eastern horizon at sunrise.

Saturn will be too close to the Sun to be visible and will move into solar conjunction on the day of the December solstice.

FIGURE 3: Star map of area around Orion



star's temperature and the elements being ionized in star's surface, known as the *photosphere*. The dark lines appear because a cooler transparent gas absorbs certain wavelengths of the light emitted from the photosphere. If there are no dark lines among the rainbow of colors, the spectra is called a *continuous spectrum*. The emission line spectra will look like bright-colored lines on a dark background.

The color of a star's spectral type reveals its temperature, from the hottest blue-white stars through the much cooler reddish stars. The spectral types listed across the horizontal axis of the H-R diagram range from very hot on the left side to relatively cool temperatures on the right side. Letters represent the different spectral types ranging from hottest to coolest (OBAFGKMLT). Each letter is further subdivided into 10 divisions using the numbers 0–9, with "0" representing the hottest temperatures and 9 representing the coolest.

Our Sun is classified as a G2-V star. Within and near Orion the Hunter are several examples of spectral classes (see Figure 3). In Orion is a red supergiant variable star with a spectral type of M1-II, a luminosity class of II, and an average apparent magnitude of 1. Down to the left of Orion is the brightest night time star, Sirius, a white-colored star with an apparent magnitude of -1.4, a spectral type of A1-V, and a luminosity class V. ●

RESOURCES

Cluster Turnoff—*http://www.spiff.rit.edu/classes/phys301/lectures/star_life/ClusterTurnoff.swf*

Colored Disks: An Interactive and Engaging Solution to the H/R Diagram—*www.mrsgeology.com/hertzsprung-russell-diagram*

H-R Diagram Worksheet—*www.miamiartscharter.net/ourpages/auto/2017/3/8/51191100/HR-Diagram-Worksheet-23cncab.pdf*

Jewels of Night—*www.noao.edu/education/jewels/home.html*

Spectral Classification—*http://astro.unl.edu/naap/hr/hr_background1.html*

Using Light to Study Planets—*www.jpl.nasa.gov/edu/teach/activity/using-light-to-study-planets*

For students

1. Explore the relationship between a star's spectral type, its color, and temperature with the practice exercises on the Spectral Classification website (see Resources).
2. Use paper plates of different colors and sizes to construct an H-R diagram on the floor or wall. (See Resources for another idea using colored disks to make an H-R diagram.)
3. Download the H-R Diagram Worksheet (see Resources) and complete the questions using the H-R diagram.
4. Follow the directions at the NASA Using Light to Study Planets website for making and using a spectroscope.

Bob Riddle (*bob-riddle@currentsky.com*) is a science educator in Lee's Summit, Missouri. Visit his astronomy website at *www.bobs-spaces.net*.