The historic stars in our skies

BY BOB RIDDLE

The *luminosity*, or apparent brightness, of some stars as seen from Earth varies over time for a variety of reasons. The luminosity of *intrinsic variable stars* is affected by changes in the physical characteristics of the stars, such as periodic expansion and contraction. The luminosity of *extrinsic variable stars* is affected by external factors, such as an orbiting body passing in front of the star.

The American Association of Variable Star Observers (AAVSO) website has locator charts for variable stars that students can print out. The charts include the *light curve* of each star, which is a visual representation of the change in magnitude of the star over a period of time (see "Variable Star Plotter" in Resources). Students may also upload their own observational data to be included in the rendering of a light curve (see Figure 1; see Resources).

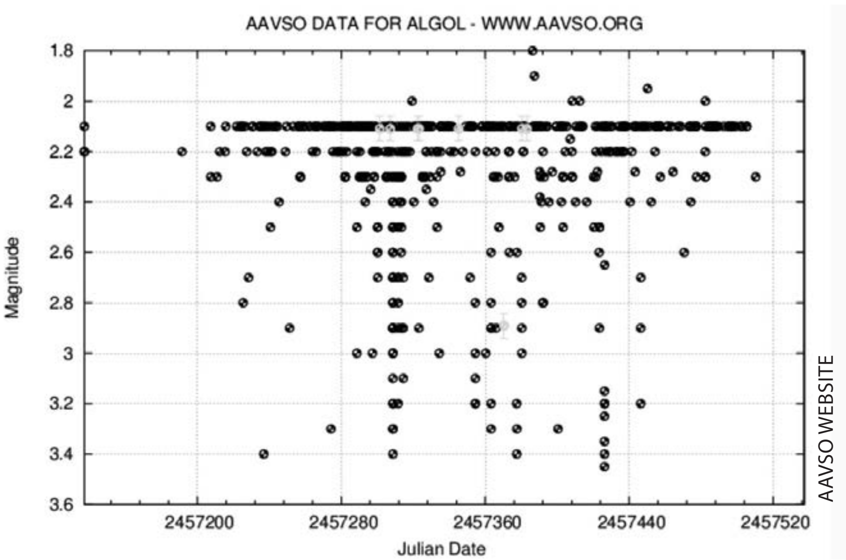
Stellar history

Dutch astronomer Johannes Holwarda discovered the first variable star and its period of variability in 1638, followed by Henrietta Levitt's discovery in 1893 that distance calculations between Earth and the star can be made from the relationship between the period of variability and the star's luminosity. This relationship later allowed astronomer Harlow Shapely to calculate distances to other galaxies and Edwin Hubble to realize that the universe is expanding.

Egyptian astronomers, however, are often credited for the first recording of a variable star more than 3,000 years ago. The Egyptians discovered what they referred to as the "Demon Star," known as an *Algol*, in the constellation of Perseus. Algol represents the eye of Medusa, the Gorgon with snakes for hair who, according to mythology, would instantly transform an onlooker into stone.

Variable stars are often described by their period of variability; they are either short or

FIGURE 1: Light curve for Algol



AAVSO WEBSITE

FIGURE 2: Dates and times for mid-eclipse magnitude of Algol

Date	Minimum time (EST)
November	
5	9:02 pm
8	5:51 pm
25	10:44 pm
28	7:33 pm
December	
1	5:22 pm
18	9:16 pm
21	6:04 pm

FIGURE 3: Dates for Mira (maximum brightness)

Year	Date
2016	March 5
2017	January 31
2017	December 29
2018	November 26
2019	October 24
2020	September 20

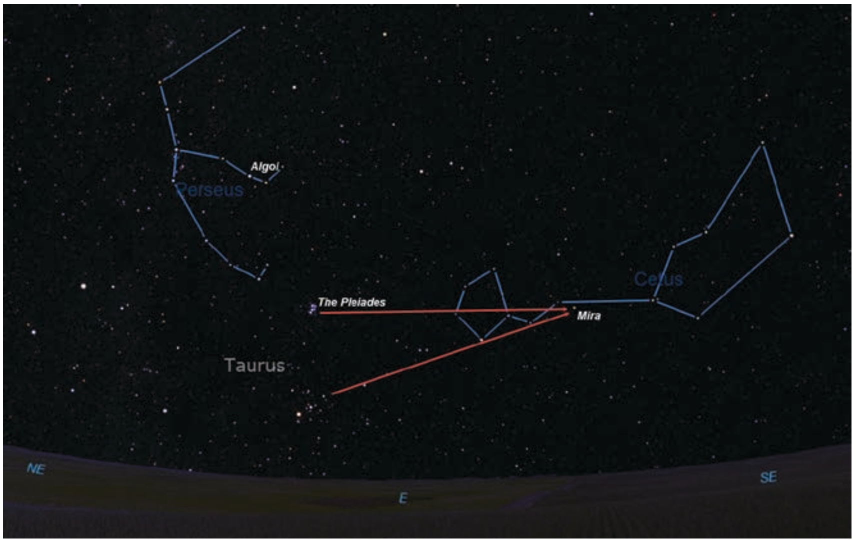
long period variables. Yet the labels *short* or *long* are relative to the type of variable star. For example, stars undergoing intrinsic or internal changes may vary in brightness in a matter of hours. However, Algol is a short-period extrinsic variable star, and there are many opportunities throughout the year to see it in action. Long-period variable stars, on the other hand, give us an idea about the future of the Sun. *Mira*, located within the Cetus constellation, is a red giant star in the later stages of its life cycle. Mira is the first star that was determined to be a long-period variable star. Interestingly, when Mira was observed in 1859 by David Fabricius, he thought it was either a nova or supernova because the star's brightness had faded considerably after a few months. Yet, as previously noted, Holwarda determined in 1638 that Mira was actually a variable star, having a period of approximately 330 days and a range from second magnitude to as dim as 10th magnitude. Negative magnitude values indicate higher magnitudes and brighter stars, while positive values indicate lower magnitudes and dimmer stars.

Billions of years from now, our Sun will become unstable and grow larger in size until it becomes a red giant, like Mira. This happens when the Sun will no longer be able to balance between the outward moving energy created by its internal fusion and the gravity holding it together. When this balance is no longer maintained, the star begins to cycle between expansion and contraction. The star begins to cool when it expands and eventually cools enough to contract. However, contraction increases pressure and heat, which once again causes expansion. The result: the Sun's apparent magnitude will vary at a rate tied to the cycle of expansion and temperature changes. The cycle of expansion will one day affect the Earth.

Variable Observations

Algol is an *eclipsing variable star*, a binary system with two stars that are larger than our Sun. Algol A, the larger of the two, is a bluish-colored star nearly 100

FIGURE 4: Location of Mira and Algol at 8 pm November 15



times as luminous as our Sun. Algol B is a yellowish-colored star several times more luminous than our Sun. Although Algol A shines at about second magnitude, its magnitude decreases to more than third magnitude when Algol B eclipses it, which happens about every three days. Teachers can demonstrate this by using the Light Curve Simulator, an online animation that mimics an eclipsing variable star and the resulting light curve (see Resources).

Algol's change in brightness lasts about 10 hours, with perhaps the most noticeable change around minimum magnitude at mid-eclipse. To witness the change in brightness, start observing Algol an hour or so before mid-eclipse, and look at it every five or 10 minutes during this time. After a couple of hours, as Algol B moves past mid-eclipse of Algol A and the magnitude begins to increase, start observing again.

Check with the AAVSO website for finder charts and times for Algol's minimum magnitudes. Winter months in the northern hemisphere are ideal for observing Algol because some nights are longer than Algol's 10-hour change in magnitude. Ideally, the minimum magnitude would occur during the evening hours, and the end of the 10-hour event would occur when it is still dark but close to dawn (see Figure 2).

This month, students could begin their observations of Mira. When observing a long-period variable, begin the month or so before the star's minimum brightness to see it change from dim to bright. While looking at Mira when it is visible during 2017, one will be able to see the star's decrease in apparent magnitude. Then, by December 29, 2017, Mira will once again be bright enough to be seen (see Figure 3). Mira and the stars in Cetus will rise after sunset. To find Mira, use the V-shaped face of Taurus and the stars of the Pleiades to create a triangle that points to it (Figure 4). At the AAVSO website, students can print a star chart and light curve for Mira, and read more about observing variable stars and why it is important and relevant, even for amateur astronomers. ●

November

- 2 Moon near Saturn and Venus
- 4 South Taurid meteor shower peak
- 6 End of daylight saving time
- 7 First quarter Moon
- 9 Moon at descending node
- 11 North Taurid meteor shower
- 14 "Super" full Moon (largest of the year)
  - Moon at perigee: 356,500 km (221,519 mi.)
  - *Cassini* flyby of Titan
- 15 Waning gibbous Moon near Aldebaran
- 17 Leonid meteor shower peak (moonlight interferes)
- 20 Neptune ends retrograde motion
- 21 Last quarter Moon
  - Moon near Regulus
  - Moon at ascending node
  - Sun enters Sagittarius
- 22 Sun enters Scorpio
- 23 Mercury near Saturn
- 24 Waning crescent Moon near Jupiter
- 27 Moon at apogee: 406,600 km (252,649 mi.)
- 28 Winter solstice on Mars
- 29 New Moon
  - *Cassini* flyby of Titan
  - Sun enters Ophiuchus

REFERENCE

Johnson, G. 2006. *Miss Leavitt's stars: The untold story of the woman who discovered how to measure the universe.* New York: W.W. Norton & Company.

RESOURCES

Allen, R.H. 1899. *Star names: Their lore and meaning.* Mineola, New York: Dover Publications (reprint).
American Association of Variable Star Observers—*www.aavso.org*
Cassini Mission at Saturn—*http://saturn.jpl.nasa.gov*
Daylight saving time—*www.geography.about.com/cs/daylightsavings/a/dst.htm*
Julian Date Converter—*http://aa.usno.navy.mil/data/docs/JulianDate.php*
Leonid meteor shower—*www.*

meteorshowersonline.com/leonids.html*
Leonid meteor storm—*www.w7ftt.net/66leonid2.html*
Light Curve Simulator—*http://astro.unl.edu/classaction/animations/binaryvariablestars/lightcurve.html*
Mars's calendar—*www.planetary.org/explore/space-topics/mars/mars-calendar.html*
Martin, M.E., and D.H. Menzel. 1907. *The friendly stars*. Mineola, New York: Dover Publications (reprint).
Mira, Omicron Ceti—*http://spider.seds.org/spider/Vars/mira.html*
NPR interview—*www.npr.org/templates/story/story.php?storyId=4738071*
SFA Star Charts—*http://observe.phy.sfasu.edu/SFAStarCharts/SFAStarChartsPro.pdf*
Riddle, B. 2009. Scope on the skies: Star light, star bright. *Science Scope* 32 (7): 82–83.
Variable Star Plotter—*www.aavso.org/apps/vsp*

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

Visible planets


Mercury will be visible over the western horizon at sunset for the first half of this month.


Venus will be visible over the western horizon at sunset.


Mars will be visible over the western horizon at sunset.


Ceres will rise after sunset local time and will be visible the rest of the night, setting one or two hours before sunrise.


Jupiter will become more visible over the eastern horizon before sunrise.


Saturn will be too close to the Sun to be easily seen. It will reappear in the morning skies after the first of the year.

For students

1. Along the *x* axis of AAVSO's generated light curve are days listed using Julian dates rather than calendar dates. For example, the Algol Minima on November 25, 2016, at 10:44 pm EST is JD 2457718.655556 in the Julian calendar. Use the Julian date converter website (see Resources) to learn more about this calendar used by astronomers and to see how other calendar dates (e.g., a birthday) would be written using the Julian calendar.
2. Star brightness, described as either apparent or absolute magnitude, is based on a numbering system that ranges from negative numbers (brighter) to positive numbers (dimmer). See "Star Light, Star Bright" in Resources for more information.
3. Students could read *Miss Leavitt's Stars: The Untold Story of the Woman Who Discovered How to Measure the Universe* or research her and other female astronomers from the Harvard Observatory around the turn of the 19th century. Henrietta Leavitt was one of several women astronomers working at the Harvard University Observatory. She and the other women were referred to as "computers," a reference to someone who did mathematical calculations. Female astronomers, considered to be more precise in their calculations, made most of the calculations to quickly and reliably process data. Often, their accomplishments and contributions to astronomy were overshadowed by the male astronomers of that time period. The book highlights the accomplishments and contributions of Leavitt and her female peers. There is also an interview with the book's author on NPR (see Resources).
4. The winter solstice on Mars occurs on November 28. How do Mars's four seasons compare with the Earth's?
5. We made a calendar for another world: Mars. So, how was the first day of the year, the "Martian January 1" determined? See "Mars's calendar" in Resources.