Variable Stars

When we look up into a clear night sky, we see the familiar vault of stars overhead, in apparently unchanging positions and with unwavering brilliance. This apparent constancy was held by ancient philosophers, Aristotle (384-322 BC) amongst them, as an indication of the "perfection of the celestial sphere". The title character in William Shakespeare's Julius Caesar even exclaims at one point, "But I am as constant as the North Star, of whose true and fixed nature there is no fellow in the Firmament". But, the stars do move slowly with respect to one another, and many stars do vary noticeably in brightness over hours to years; these are (predictably) referred to as **variable stars**. The North Star (so-named because it sits very close to the North Celestial Pole at the end of the Little Dipper's tail, and is always in the North as the Earth's rotation causes the rest of the sky to rotate around it), **Polaris**, is actually a weak variable; and so Caesar was unwittingly referring to himself as an unstable fellow – which, of course, he proved to be.

There are many reasons why stars appear to regularly, or irregularly, change in brightness, and thus many kinds of variable star. If we wish to quantitatively measure stellar brightnesses, it first helps to have a unit of measurement. The ancient Greek astronomer Hipparchus (190-120 BC) devised the system we use to this day. He divided the brightnesses of the 4000-odd stars visible to the human eye, into five **magnitude** bins, with lower magnitudes corresponding to brighter stars (think of lower times for the fastest Olympic athletes; 'the brightest stars' (sic). First magnitude stars are the most conspicuous, and the faintest you can casually see without aid are about fifth magnitude. It turns out that this covers a brightness range of about 100, with each lower magnitude being about 2.5 times brighter than the last. To be more rigorous, apparent stellar magnitudes are measured quantitatively in several colours through **photometric filters**; so we can speak of a star's apparent **B** ("blue"), **V** ("visual", in practice the same yellow-green light the human eye sees at night), or **R** ("red") magnitude. The bright white star Vega in the Summer Triangle defines "zero magnitude" in all these filters. The brightest star we see in the night sky is Sirius, and it has an **apparent visual magnitude (mv)** of -1.4. The full Moon appears to shine with the light of a star of apparent visual magnitude -11; for the Sun, about -26! In contrast, a long exposure photograph at a telescope may see stars down to magnitudes of +20 or even fainter; the Hubble Space Telescope, above the Earth's atmosphere, has seen down to +29 and beyond.

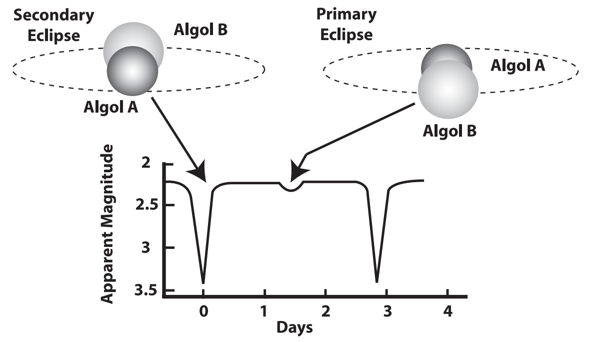
So what are some examples of variable stars, why do they vary, and why is this fascinating to so many people? Last first; understanding stellar variability is key to understanding how stars "tick", and some classes of variable stars are crucial to establishing the distance scale in the universe. Many are also bright enough that anyone can track their changing brightness without any special equipment (a recommended list of the Top Twelve Naked Eye Variable Stars is at Sky & Telescope magazine online, at

http://www.skyandtelescope.com/observing/objects/variablestars/3304276.html)

Variable stars are of many types, but there are two broad catagories; those who's light output intrinsically varies (typically single, giant stars that **radially pulsate**), or those which are actually unresolved binary pairs of stars as seen edge-on from Earth, so that they periodically eclipse one another (**eclipsing binaries**). The various classes of variable star are distinguished by changes in their observed **light curves**, and are typically named after the prototype example discovered. (There are also several more exotic forms of periodic and semiperiodic intrinsic variables, but few of these are naked eye.)

The first star documented by Europeans to be variable is Omicron Ceti (the 15th brightest star in the constellation Cetus the Whale). First noted to be variable by astronomer David Fabricius in 1596-1609, Johannes Holwarde determined the period to be about 11 months (332 days) in 1638, and at the same time Johannes Helvelius named it **Mira**, Latin for "wonderful". At its brightest this star can peak at a visual magnitude of about 3.5 (in February of 1997 it was especially bright at magnitude 2.5), and it disappears at its faintest (to a magnitude of 8.6 to 10.1). Mira-type variables are the longest-period class of **pulsating variables**, with periods of 80 to 1000 days, and all are supergiant stars whose gravity only has a tenuous grip on these stars' outer layers. Most stars evolve to become giants (and the larger ones, supergiants), and during this phase can become unstable and pulsate, becoming more luminous when puffed-up and less-so when contracted. Possibly the brightest example of a Mira variable is the red supergiant star **Betelgeuse**, in the shoulder of the Winter constellation Orion the Hunter, though it doesn't vary much; mv changes from 1.0 to 0.3 over six years.

The second star documented to be variable, by Geminiano Montanari in 1669, turned out to be of the eclipsing type, famous **Algol**, or Beta Persei – the second brightest star in the constellation Perseus. Like clockwork, every 2.87 days its apparent visual magnitude dips from 2.1 to 3.4 for about 10 hours, as one star in the pair eclipses the other. Following the **"Minima of Algol"** is a simple and rewarding Fall project for those in the Northern Hemisphere, and the predicted times are charted in many astronomical publications. When observing, compare its brightness



AGOL STAR SYSTEM

with other nearby, non-variable stars (a star chart with labeled magnitudes is handy). A class of very close eclipsing binaries is typified by bright **Beta Lyrae**, near Vega in the Summer constellation Lyra the Harp. Here the two co-orbiting stars are so close together their mutual gravity distorts them into nearly-touching ellipsoids; unlike that for Algol, the **light curve** varies smoothly with mv dimming from 3.3 to 4.4 every 12.94 days with a lesser dip mid-cycle. Another famous eclipsing variable is Epsilon Aurigae, the fifth-brightest star in Auriga with an apparent visual magnitude of about 2.9 to 3.8; here, however, the period is 27.12 years, with the eclipse phase lasting from 640 to 730 days. While first described as weirdly variable by Johann Fritsch in 1821, and studied intensely by many ever since, astronomers are still not quite sure of what's going on here. One possibility is that the occulting star is more like a cloud; another is that the primary star is surrounded by a clumpy disk, and is variably eclipsed by it as we view it edge-on. Happily, a new eclipse cycle of **Epsilon Aurigae** has just started this past August (2009), and you can join many world-wide public observing campaigns and contribute to real science by monitoring this star (and/or others, of course), and submitting your results to the American Association of Variable Star Observers (AAVSO) at www.aavso.org.

Possibly the most significant kind of pulsating variables are the **Delta Cepheids**, named after the prototype, the fourth brightest star in Cepheus, the King, discovered to be variable by John Goodericke in 1784. Delta Cephei's light curve is saw-tooth shaped, varying from an apparent magnitude of 3.5 to 4.5 over 5.37 days. Cepheids have periods of days to weeks. In 1908 the Harvard astronomer Henrietta Swan Leavitt, studying thousands of variable stars in the Large Magellanic Cloud (now known to be a satellite galaxy of our Milky Way), discovered that the Cepheids' periods and apparent magnitudes were tightly correlated, with the brighter ones having longer periods. Because they were all about the same distance away from Earth, this meant that their intrinsic brightnesses could be determined simply by measuring their periods; this makes Cepheids an indispensable means of measuring distances in the near Universe. In 1924, when Sir Edwin Hubble first resolved Cepheids in the Great Andromeda Galaxy M31, it was finally determined that this object was 2 million light years away, and so was another galaxy outside of our own, and not just a nebula within it. The famous **Hubble Space Telescope** was constructed, in part, to resolve Cepheid variables in much further galaxies, concretely extending the distance scale ever further. Polaris, mentioned earlier, turns out to be a weak Cepheid (0.03 magnitudes over 2.97 days).

There are many more exotic types of variable star, where variability may be caused by giant "star spots" rotating in and out of view (**BY Draconis** stars), or by semi-regular giant "solar flares" (**flare stars**, such as Proxima Centauri – all faint red dwarfs), and then there are **cataclysmic variables** such as **novae** (where material falls onto the surface of a white dwarf and periodically flashes in an explosion). All are fascinating in their own right, and collectively, variable stars provide enormous insight into the workings of stars and our Universe.

Chris Stevenson RASC, St. John's Centre

ACTIVITIES

1. The above article talks about variations in the stars, can you find any other types of variations in The Telegram?

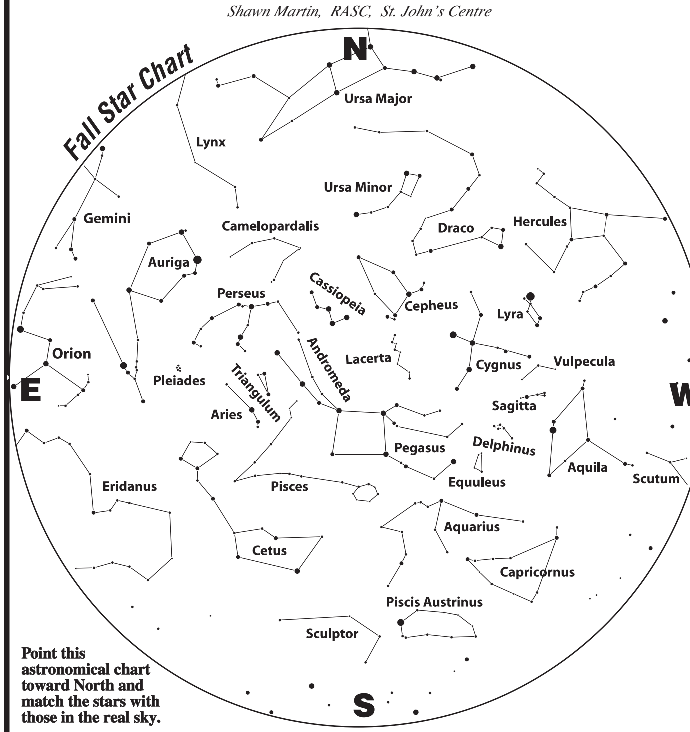
2. Viable stars are carefully observered to better understand their nature. Find an example of better understanding a person, place or thing, though observations made in The Telegram?

For more activities go to ***www.thetelegram.com*** and click on **Our NIE Program**

What's Up

Nov. 20 - Mid December

Shawn Martin, RASC, St. John's Centre



Planets

Viewable in a pair of binoculars or small telescope

Mercury - is hiding deep in the sunset.

Venus - (magnitude –3.9) is sinking very low in the dawn. Look for it above the east-southeast horizon.

Mars - (magnitude +0.2, in Cancer) rises around midnight and is very high in the southeast before dawn.

Jupiter - (magnitude –2.6, in Capricornus) (magnitude –2.4, in Capricornus) shines brightly in the south in twilight, and lower in the southwest later in the evening.

Saturn - (magnitude +1.0, in the head of Virgo) is up the southeast before and during dawn.

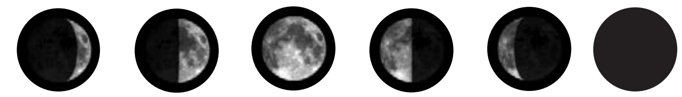
Uranus - (magnitude 5.8, below the Circlet of Pisces) is highest in the south during evening.

Neptune - (magnitude 7.9, in Capricornus) is 5° east of Jupiter.

Pluto (dwarf planet) - is lost in the sunset.

Moon

Waxing	First Quarter	Full	Last Quarter	Waning	New
Nov. 22	Nov. 24	Dec. 3	Dec. 8	Dec. 10	Dec. 16



Meteor Shower

Geminids Dec. 13/14 This meteor shower gets the name "Geminids" because it appears to radiate from the constellation Gemini. The Geminids meteor shower will peak on the night of December 13/14, at 50-80 meteors per hour. Look towards the east on December 13 at around 9 - 10 p.m. toward the constellation Gemini, the viewing should be very good as there will be no moon to wash out the dark night sky. (Gemini can be seen on the star chart above).

You can contact the Royal Astronomical Society of Canada, St. John's Centre, at www.rasc.ca/stjohns/

WARNING! When using a telescope or binoculars, always be sure NEVER TO LOOK AT THE SUN! This can cause serious and permanent eye damage. To be safe, always make sure the Sun is fully set below the horizon before going outside with your telescope or binoculars.