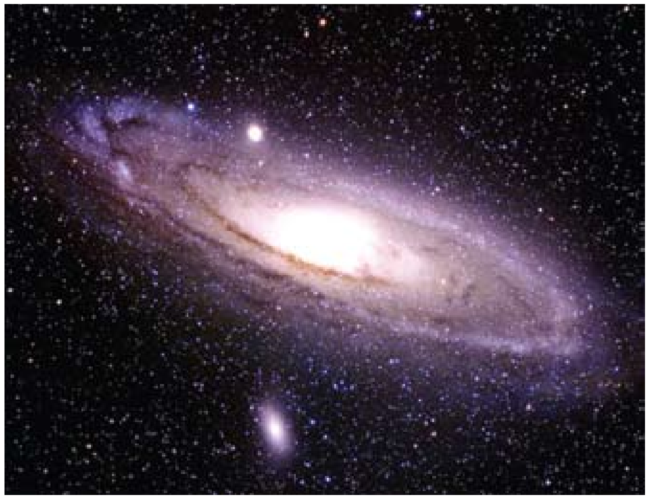
Star light, star bright

by Bob Riddle



PHOTOGRAPH COURTESY OF NASA

Andromeda galaxy

Measuring stellar distances

We all know something about the idea of light-years and the idea of looking back in time as we observe the light from distant celestial objects. Light travels at 186,000 miles per second (~300,000 km/sec.). At that speed, it takes sunlight approximately eight minutes to reach the Earth after traveling about 93 million miles. The next closest visible star, Alpha Centauri, is part of a triple-star system in the southern constellation of Centaurus, the Centaur. Light from that star takes about 4.3 years at the speed of light to reach our eyes. On an even grander scale is the Andromeda, a galaxy large enough and close enough to be seen with the unaided eye. The light from that galaxy travels more than two million years (or more than two million light years) before reaching the Earth. If we know how long it takes light to travel distances, then how do astronomers measure distances to celestial objects?

Stellar magnitudes

How bright a star appears is directly related to its temperature, size, and its distance from us. Of the three, we cannot really determine size by simply looking at stars with only our eyes. We may infer temperature by observing the star color in a range from a cooler red to a much hotter blue-white. Estimating distance to a star is somewhat more of a challenge because, for example, a star that appears bright may be a close, small, hot star, or it may be a distant, huge star. However, the relative distance to a star can be determined by comparing two different measurements of the stars' brightness.

In astronomy, the brightness of a star is described in terms of the star's magnitude. Stellar magnitude is expressed two different ways, using the terms *apparent magnitude* and *absolute magnitude*. For both magnitudes, the numbering scale is the same, with negative numbers being brighter stars and positive numbers being dimmer stars. Each change in magnitude numbers represents a 2.51 times difference in magnitude. In one direction is the Sun with an apparent magnitude of nearly –27; the full Moon at –13; Venus at around magnitude –4; and Sirius, the brightest night time star, at –1.5. In the other direction, as numbers go from 0 and higher, the magnitude of the star decreases, the star gets dimmer, again at 2.51 times for each magnitude difference. Under really dark sky conditions, the limit for seeing dim stars is approximately 6th magnitude.

Apparent magnitude is how bright the star appears at its true distance. It's sort of like saying, "That's the brightest-looking star, and there is the second-brightest star," and so on. This is a scale devised many, many centuries ago that described stars from the dimmest at 6th magnitude, to the brightest at 1st magnitude. This system, with little modification, survived for nearly 1,500 years until Galileo, with his new telescope, realized that there are stars dimmer than 6th magnitude, and the scale increased to include dimmer stars now visible through the telescope. As telescopes became more powerful, even dimmer stars were recorded. It became obvious that a more precise system was needed, and by the 19th century, with the use of photometers, the apparent magnitude scale was adjusted more precisely than had been previously done using naked-eye appearance. One standard adopted was that a difference of 5 magnitudes would equal a brightness difference of 100. The fifth root of 100 is approximately 2.51, so a 5-magnitude difference, in effect, is the same as 2.51 × 2.51 × 2.51 × 2.51 × 2.51=100.

Absolute magnitude is how bright the star would appear if it were at a distance of 10 parsecs, or about 32.6 light-years. Unlike *apparent magnitude*, distance is not a factor, as all stars are placed at the same 10 parsec distance for comparison. By comparing the apparent magnitude with its absolute magnitude, the distance to a star could be described relative to 10 parsecs: closer than 10 parsecs, equal to 10 parsecs, or farther than 10 parsecs.

- If the apparent magnitude is the same as the absolute magnitude, the distance is 10 parsecs, because the star appears to be as bright as it is at 10 parsecs.
- If the apparent magnitude is brighter than the absolute magnitude, the star must be closer than 10 parsecs, because it appears brighter than it would at 10 parsecs.
- If the apparent magnitude is dimmer than the absolute magnitude, the star must be more than 10 parsecs, because it appears dimmer than it would at 10 parsecs.

Dark skies

One of the greatest challenges to observing our skies at night has to do with the effects of light pollution. Fortunately, there are solutions and resources readily available. The International Dark-Sky Association (IDA) has a website with information students can use as they research light pollution (see Resources). Students can learn more about light pollution by reading "Aunt Nan's Missing Star," a short story I wrote for the Mid-Continent Council of Girl Scouts as part of a light-pollution project (see Resources). On the GLOBE at Night Project website, students can learn how to do a star count at their home or school and include that information in a database on the website (see Resources).

Visible planets

Mercury will be visible over the eastern horizon before sunrise for most of the month.

Venus will be very visible over the western horizon at sunset, setting several hours later.

Mars will start to become more visible over the eastern horizon before sunrise.

Jupiter will outshine Mercury and Mars as it rises in between them this month.

Saturn will rise after sunset and will be located over the southwest horizon at sunrise.

March

4	First quarter Moon
7	Moon at perigee: 367,020 km
8	Spring forward: Start daylight savings time
	Saturn at opposition
11	Full Moon
13	Uranus in conjunction with the Sun
15	Dwarf planet Makemake closest to Earth
18	Last quarter Moon
19	Moon at apogee: 404,302 km
20	March equinox
22	Moon near Jupiter
24	Moon near Mars
26	New Moon
27	Venus at inferior conjunction
	Cassini spacecraft flyby of Titan
31	Mercury at superior conjunction

Questions for students

1. Explain how our Sun appears to be the largest and brightest star in the sky. (*The Sun is the closest star, so it appears to be the largest and brightest star.*)
2. The star Sirius in Canis Major is the second-brightest star in the sky, or the brightest star at night. How would our Sun and Sirius compare if they were both 10 parsecs away? (*Sirius has an apparent magnitude of -1.46 and an absolute magnitude of 1.43. The Sun has an apparent magnitude of –27 and an absolute magnitude of 4.75. Sirius is nearly 3 magnitudes [almost 18 times] brighter than the Sun when both are placed at the same distance of 10 parsecs.*)
3. A star has an apparent magnitude of –1 and an absolute magnitude of 1. Is this star 10 parsecs away, or is it closer or further than 10 parsecs, and how would you know? (*Because the star appears brighter at its actual distance than if it were at 10 parsecs, then it must be closer than 10 parsecs.*)
4. Use the Brightest Stars list (see Resources) as a source of apparent and absolute magnitudes to give to students. Students would then determine relative distances (less than 10 parsecs, 10 parsecs, more than 10 parsecs, way more than 10 parsecs) and sort stars from closest to most distance.

Resources

Aunt Nan's Missing Star—*http://currentsky.com/articles/nan*
Brightest Stars—*www.astro.uiuc.edu/~kaler/sow/bright.html*
Cassini Mission—*http://saturn.jpl.nasa.gov*
Dawn Mission—*http://dawn.jpl.nasa.gov*
GLOBE at Night Project—*www.globe.gov/GaN*
International Dark Sky Association—*www.darksky.org*
International Year of Astronomy—*www.astronomy2009.org*
SFA Star Charts—*http://midnightkite.com/starcharts.html*

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