Sunset Astronomical Society

The Sunset Gazette

Serving the Tri-Cities since 1975

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Meeting information

Meetings are generally in the theater in the Delta College Planetarium in Bay City. The meetings will usually be on the 2nd Friday of each month at 7:00 PM. Watch the newsletter for changes in dates and times. Membership is not required to participate in meetings and activities. See last Page for this month's meeting site.

Membership Information

Our club has switched to e-mailing our newsletters. For those wishing to receive a hard copy mailed an additional dues of $10.00 per year is required.

Student / Senior: (17 years & younger, 65+ years)

1 year - $15 (mailed Newsletter add $10)

2 year - $20 (mailed Newsletter add $10)

Regular: (18+ years)

1 year - $20 (mailed Newsletter add $10)

2 year - $30 (mailed Newsletter add $10)

Family:

1 year - $25 (mailed Newsletter add $10)

2 year - $40 (mailed Newsletter inclusive)

Membership includes voting privileges, the newsletter and free admission into Delta College Planetarium shows.

Treasurer's address for renewals and subscriptions:

Tom Smith, 3423 Hidden Road,

Bay City, MI 48706-1243

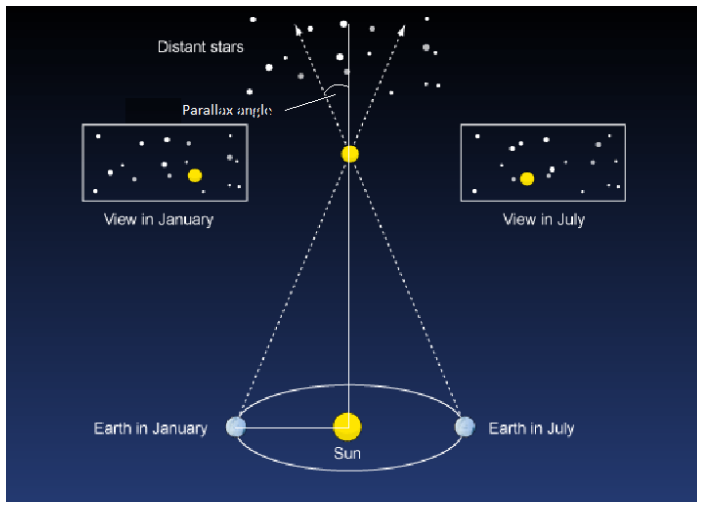
Subscription Information

Subscription prices for "Sky and Telescope" Magazine or "Astronomy" Magazine are available at club rate with the purchase of individual or family membership. For prices please refer to the treasurer or the club's website:

http://www.sunsetastronomicalsociety.com/SASMembership.htm

Measuring Astronomical Distances Over The Centuries

This new series is about how astronomers determined and measured distances to astronomical objects over the course of more than two thousand years. The series will span from the beginnings in Greek antique to the latest development using earth and space based telescopes.



In the last issue we covered how astronomers determined the distance to the closer stars by measuring their yearly parallax. We remember this is the angle under which the star appears in relation to even more distant stars. The angle is measured 6 months apart using the Earth-Sun distance as the baseline in a right angle triangle (see left picture). We also learned that the determination is the second step in the **cosmic distance ladder** (the first one is the astronomical unit AU). These are the only two steps which can be measured directly, all other steps are determined by indirect methods building on these first two steps. Over the last decades several methods have been developed to improve the parallax method. Here are some of the most important:

Statistical parallax method: The stars in the milky way do not all have the same motion and radial velocity in relation to our Sun. The motion can be determined by plotting their positions over a time frame of many decades whereas their radial velocity (the motion towards or from us away) can be determined by the Doppler shift. If the spectral lines of these stars are shifted to the red (= larger wavelengths) the stars move away from us where if their spectral lines are shifted to the blue (= shorter wavelengths) the stars moving towards us. If a group of stars has the same spectral lines and are of similar magnitude a mean parallax can be determined from statistical analysis of the proper motions relative to their radial velocities. This method is especially useful for measuring bright giant variable stars like RR Lyrae and Cepheids at distances beyond 50 parsecs (>150 light years).

Secular parallax method: When the Sun moves through space it will provide a longer baseline which corresponds to 4 AU per year for the stars in our milky way, whereas for the far more distant stars in the milky way halo the baseline will increase to 40 AU per year. After several decades the baseline will increase to being several orders of magnitude larger than the Earth-Sun distance. The disadvantage is that the secular parallax is not as accurate as the original parallax because the movement of the stars does introduce a certain amount of error.

Moving cluster parallax method: This method uses the motion derived form astrometry of individual stars in a nearby star cluster to determine their distance. Needed are the angular motions and the motions from the Doppler shifts which then allows the estimation of the distance. The technique can only be used on near enough open clusters like the Hyades. This measuring of the distance of this cluster in particular has been quite an important step in the distance ladder.

Expansion parallax method: In this technique the expansion of a gas cloud like a planetary nebula or a supernova remnant is observed over many years or even decades. Using again the Doppler shift the speed of the expanding gas can be determined and with the angular increase of the object, determined by observation, the distance can be estimated. The same method can be used for binary stars which are both visual and spectroscopic binaries. By measuring the angular motion combined with the absolute velocity (Doppler effect) the distance can be estimated. Especially supernova ejecta are very useful because of their large expansion velocities, their brightness and physical sizes. These ejecta can be measured with radio interferometers which can determine very small angular motions. It is possible, albeit rare, to use this method to measure distances to supernovae in other galaxies. This gives yet another important piece of information to back check against other methods on the cosmic distance ladder.

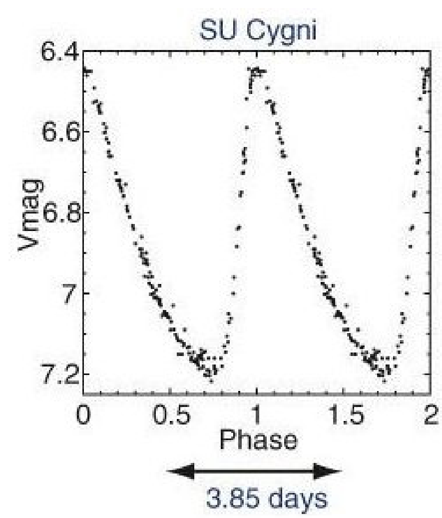
Now we have to talk about **Standard Candles**, a term which you may have already heard or read about. In fact all physical distance indicators are standard candles. If an object has a known luminosity and if that luminosity is then compared to its observed brightness the distance of the object can be determined using the inverse square law. So how does this work? In astronomy the brightness of an object is given in terms of its absolute magnitude **M** , which is derived from the logarithm of its luminosity as seen from a distance of 10 parsecs (32.62 light years). The next thing you need is the apparent magnitude **m** which is the magnitude as seen by the observer. From that you can then calculate the distance D by using the following relationship:

$$5 \cdot \log_{10} \frac{D}{\mathrm{kpc}} = m - M - 5,$$

In addition you have to take in account the interstellar extinction, which will make objects fainter as they really are.

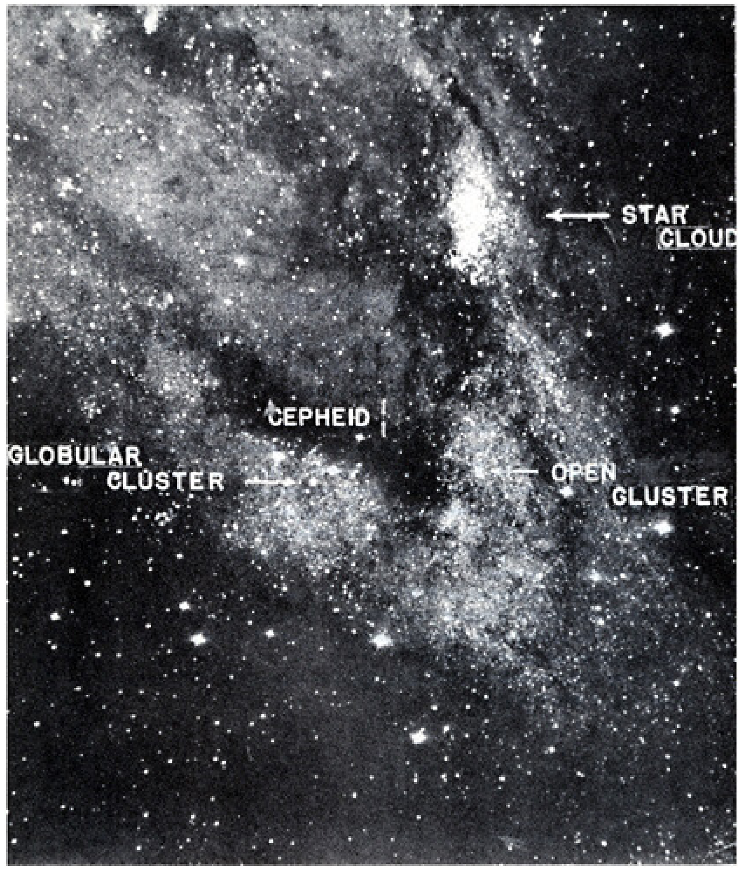
Of course no method comes without problems: The main issue with the standard candles is knowing the true luminosity and therefore the absolute magnitude of the object. One famous example are the type 1a supernova used to determine the largest of distances and are absolutely critical to determine the correct cosmological model (e.g. does the expansion of the universe accelerate or slow down over time?). Therefore it is crucial to know if the more distant supernovae 1a have the same properties than the nearby supernovae, because only if they have the two will have the same absolute magnitude.

The other main issue is to determine the true class of the object and not mistakenly using an object which does not belong to the class. This recognition problem is getting more serious the more distant the objects are. A famous example can be found when one looks at the history of distance measurements using the famous Cepheid variables. These stars are a class of very luminous variable stars which have an interesting mechanism for the pulsation also known as Eddington valve. It is now acknowledged that helium in the stars outer hull is responsible for their pulsation. Helium is a novel gas and has two protons and two neutrons as its nucleus and two electron in its sphere. When helium is heated in can first lose one (= singly ionized helium) and then both of its electrons (= doubly ionized helium). It turns out that doubly ionized helium is more opaque concerning radiation than singly ionized helium. Also the more helium is heated, the more ionized it becomes. At the dimmest part of a Cepheid's cycle when the Cepheids diameter and surface is the smallest, but its outer layers are the hottest, the ionized gas in the outer layers consist mainly of doubly ionized helium. This makes the outer layer of the star more opaque for radiation and they begin to heat up and expand. As the hull expands the star becomes brighter but it also cools, and so the helium becomes less ionized and therefore more transparent for radiation, allowing the heat to escape. Once the heat is gone the expansion stops, and the hull contracts due to the star's gravitational attraction and the star becomes dimmer again. The gravitational attraction then starts heating the outer layers and repeats the whole process. See right picture!



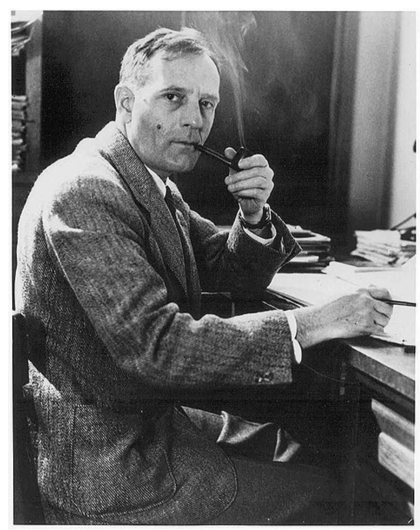
Light Curve of a Cepheid.

What makes Cepheids so important as standard candles is their strong direct relationship between their luminosity and pulsation period. But Cepheid variables come in different forms and are now divided into several subclasses. These subclasses are distinguished by different masses, ages, and evolutionary histories and the different Cepheides are called Classical Cepheids, Type II Cepheids, Anomalous Cepheids, and Dwarf Cepheids. The failure to distinguish between these subclasses lead to a significant problems with the astronomical distance scale in the early-to-mid 20th century.



Cepheids identified on a photographic plate of the Andromeda Galaxy.

Because Cepheids have been and still are so important we will look little bit into their history which is actually quite interesting. The term *Cepheid* originates from the star Delta Cephei situated the constellation Cepheus and it was the first star of this type identified by John Goodricke in 1784. In 1908 Henrietta Swan Leavitt (see picture below) discovered the relationship between the period and luminosity for classical Cepheids when she investigated thousands of variable stars in the Magellanic Clouds (see left picture). A few years later Harlow Shapley used Cepheids to determine the shape and size of our own Milky Way and where our Sun would be positioned within it. In the mid-twenties Edwin Hubble (see picture right) used Cepheids in the Andromeda Galaxy to determine its distance and to settle once and for all the debate if the Milky Way and the Universe were the same or if some of these faint nebulas were in fact huge galaxies of their own and lie far beyond our Milky Way.



By combining Cepheid distances to several galaxies with Vesto Slipher's measurements of the speed at which those galaxies recede from us, Edwin Hubble and Milton L. Humason formulated the first version of Hubbles's law albeit with a velocity constant which were nearly an order magnitude larger than what is accepted today. This also led to the discovery that the universe is expanding. In the 1940s Walter Baade realized that things were not quite as simple and that Cepheids actually consist of at least two separate populations: what is now known as Classical Cepheids and Type II Cepheids. The Classical Cepheids are younger and more massive population I stars, whereas Type II Cepheids are older fainter population II stars. What is even more important Classical Cepheids and Type II Cepheids follow quite different period-luminosity relationships. So is the luminosity of Type II Cepheids about 1.5 magnitude less than that of the Classical Cepheids. The initial distances derived form Cepheids were jumbled because both populations were taken into account and thought to be one and the same. This had the result that the initial distance of M31 was assumed to be only 1/4 of the today's distance (2.1 million light years). It also resulted in the doubling of the Milky way diameter and readjustment of the Hubble constant (which by the way turned out be anything but a constant over the last 80 years).

In the next parts of this series we will learn more about the **cosmic distance ladder** and how recent measurements lead to some quite unexpected findings in cosmology.

SUNSET ASTRONOMICAL SOCIETY
THE SUNSET GAZETTE
SERVING THE TRI- CITIES SINCE 1975

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This issue can be accessed in color on the website of the SAS!!!
http://sunsetastronomicalsociety.com

SAS Meeting

Start: 7:00 PM

Friday, June10th, 2011

Delta Planetarium

1. **Welcome, new members**
2. **Evening's theme:**

   "TBD"
3. **Club Stuff**

What's up in the Sky

June 3-5 *Dusk:* Waxing Moon below Castor and Pollux (3rd), between Pollux/Castor and Procyon (4th), and left of Pollux/Castor on 5th.

June 8: 1st quarter Moon

June 9-11 *Evening:* Waxing gibbous Moon passes below Spica and Saturn.

June 14 *Evening:* Antares right of the Moon.

June 15: Full Moon.

June19-22 *Pre-Dawn:* Mars and the Pleiades can be found in 5 deg field of view in the east-northeast ca 25 deg to the lower left of Jupiter.

June 21: Longest Day of the Year in Northern Hemisphere.

June 23: Last quarter Moon

June 28 *Dawn*: Below and above the thin crescent Moon Pleiades and Mars can be found.

June 29 *Dawn*: A triangle is formed by the very thin crescent Moon, Mars and Aldebaran. Best observed about 45 min before sunrise.

June 30 *Dawn*: Watch out for an extremely thin crescent Moon 1 to 3 deg to the lower left of bright Venus just above the east-northeastern horizon at about half hour before sunrise. You will need clear air, an unobstructed horizon and probably binoculars (big help!).

July 1: New Moon.

July 1-19 *Dusk***:** Mercury fairly well placed for observation ca 8 deg above the west-northwestern horizon a half hour after sunset.

July 2 *Dusk***:** Very thin crescent Moon can be spotted to Mercury's upper left and below Regulus. Binoculars!

July 6-8 *Evening***:** Moon passes below Saturn and Spica.

UPCOMING EVENTS

July, exact date TBD: On the Hill at Sue's

September 22 - 25: Great Lake Star Gaze 9 at River Valley RV Park