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

Elections for SAS officers at the next SAS meeting on Friday May 13th!!!

Anyone interested in an office can contact

Steve VanTol @ stevenv106@aol.com

or call his home tel 989-96-3541

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 looked into ways how the astronomers measured the distance from the Earth to the Sun and how they slowly managed to get ever better values for the astronomical unit AU (mean distance between the Earth and the Sun and is equal to about 149,597,870.7 km or 92,955,807.27 miles). Here comes the concluding part:

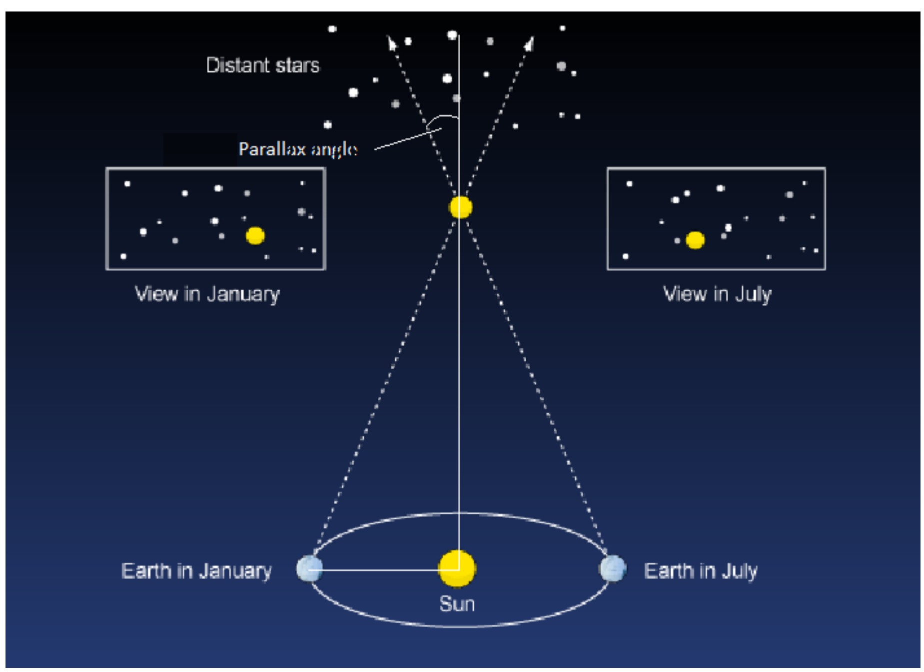
After the invention of the telescope far more accurate measurements of angles were possible than with the naked eye. This was taken advantage of by the Flemish astronomer Godefroy Wendelin. In 1635 he repeated Aristarchus' measurements and found that Ptolemy's value of 1210 Earth radii was too low by a factor of at least eleven. In the next couple of centuries the transit of the Venus in front of the Sun was used by many astronomers to make more accurate measurements of the Earth - Sun distance.

The transit is measured in two different locations and from that the parallax of Venus can accurately be calculated. In a second step the solar parallax *α (*which cannot be measured directly) can be calculated from the relative distance of the Earth and Venus from the Sun. In 1639 a Venus transit enabled Jeremiah Horrocks to produce an estimate of 15 arc seconds for the solar parallax which is equivalent to a Earth - Sun distance of 13,750 Earth radii. Later Christiaan Huygens estimated the distance to be even greater: He compared the apparent sizes of Venus and Mars and arrived at a value of about 24,000 Earth radii, which is equivalent to a solar parallax of 8.6". This estimate is remarkably close to modern values, but because of the many (unproven) assumptions he made the accuracy of his results seems to be more based on luck than good scientific measurement.

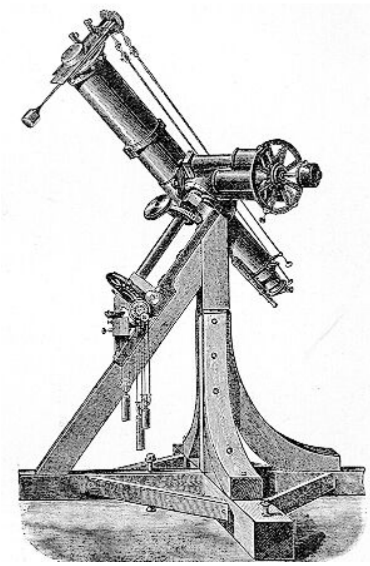
A better value was derived by Jean Richer and Giovanni Cassini by measuring the parallax of Mars between Paris and Cayenne in French Guyana during the time when Mars was at its closest to Earth in 1672. The result was a solar parallax of 9½", which translates to an Earth–Sun distance of about 22,000 Earth radii. In 1672 James Gregory published a more advanced method for observing Venus transits in his *Optica Promata* which was strongly favored by Edmond Halley and used in the transits of Venus observed in 1761 and 1769, and then again in 1874 and 1882. Observing the transits in 1761 and 1769 was quite an scientific endeavor not alone because of the raging 7 year war which can actually be described as the first real world war with fighting between England and France and their respective allies in Europe, the American colonies and Asia. Many astronomers were sent to observing points around the globe and the results were collected by Jerome Lalande to arrive at a value for the solar parallax of 8.6". A better method is the determination of the aberration constant by which Simon Newcomb derived at a widely accepted solar parallax value of 8.80" (quite close to the modern value of 8.794143"). The first direct measurement of the Earth - Sun distance in kilometers was achieved by the collaboration of Newcomb with A. A. Michelson to measure the speed of light with Earth-based equipment and combining it with the aberration constant (which is related to the light time per unit distance). Around 1903 the name "astronomical unit" seems to have been used for the first time.

The determination of the astronomical unit also made it possible to tackle the next great distance problem: What is the distance to the stars?

The distances to the nearest stars can be measured via the **stellar parallax.** As the Earth orbits around the Sun over the years, the position of nearby stars will appear to shift slightly against the more distant background stars (see picture on the left). The Earth, the Sun and the star form a right triangle with the Earth - Sun distance = 1 AU as the short leg of triangle.



The amount of shift is really small: For an object at a distance of 1 parsec (= 3.262 light-years) the angle is 1 arc second and decreasing the further the star is away. The distance to an object is the reciprocal of the measured parallax: $d(\text{pc}) = 1 / p$ (arcsec). The angle under which the next star Proxima Centauri shifting against the star background is only 0.7687 arc seconds, its distance is therefore 1/0.7687=1.3009 parsecs or 4.243 light-years. To give you an example how small that angle is think about an object 4/5 inch in diameter located 3.3 miles away. Because the stellar parallax is so small and so difficult to measure it was actually used as a scientific argument against the heliocentric system: It was clear that the effect would be very small and undetectable if the stars would be very far away. But why should they?



Tycho Brahe argued that there was no reason why the 8th sphere (in the Ptolemaic system) , the sphere which was assigned to contain the fixed stars would be separated by such an incredible large void from the inner spheres where the planets were circling. The lack of an observable stellar parallax let him and others object the Copernican heliocentrism. The first one who tried to measure the stellar parallax in earnest was James Bradley, an English astronomer who served as Astronomer Royal from 1742, succeeding Edmund Halley. In 1729 he tried to measure stellar parallaxes but the movement of the stars proved to be too small for his instruments. It should take more than another century and further improvement of the observational instruments till the first successful measurement of a stellar parallax was made by Friedrich Bessel (see right picture) in 1838 for the star 61 Cygni using a Fraunhofer heliometer (see left picture) at the observatory in Königsberg (today's Kaliningrad).

The difficulty to measure stellar parallaxes is displayed in the fact that only 60 parallaxes of the nearest stars had been obtained till the end of the 19th century! In the 20th century this process was sped up by astrographs using photographic plates. In the 1960s the more sophisticated computer technology and automated plate-measuring machines allowed the compilation of large star catalogues. And in the 1980s the advent of CCDs replaced the photographic plates and reduced optical uncertainties to one milli arc-second. Till today the stellar parallax remains the standard calibration for all other distance measurement methods and the only way to directly determine the distance to a cosmological object. In 1989, a small revolution occurred with the launch of the satellite Hipparcos (**hi**gh **p**recision **par**allax **co**llecting **s**atellite") who was a scientific mission of the European Space Agency (ESA) and operated between 1989 and 1993. Its task was to obtain the parallaxes and proper motion of nearby stars and to extend the trigonometric stellar parallax method by a facto of ten. Hipparcos was able to determine stellar parallaxes up to a distance of 1600 light-years which is still little more than about 1 % of the entire milky way. A quantum leap is planned with the launch of Gaia, another European Space Agencies mission, due for launch early 2013. Its mission will be to create an extremely precise three-dimensional map of over a billion stars throughout our Milky Way galaxy and beyond. The accuracy will be in the micro arc-seconds and enables Gaia to measure distances in the tens of thousands of light years. It will also map the motions of theses stars which is important because the motion has encoded the origin and subsequent evolution of these stars and subsequently that of the Milky Way.

The important fact to take home is that the AU and secondly the stellar parallax are the first two steps on the **cosmic distance ladder** and are vital to all other measurements. The **cosmic distance ladder** which is also known as the **extragalactic distance scale** is the succession of methods by which the distances to astronomical objects are determined. As we have already learned there is no one technique which can measure distances at all ranges encountered in astronomy. Instead the ladder analogy arises because as one method can be used to measure nearby distances like the AU, a second can be used to measure nearby to intermediate distances (stellar parallaxes), and so on.

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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Elected Officers for the SAS:

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2. Vice President, Tim Ross tjrastronomy@hotmail.com

Treasurer, Thomas Smith tom55net@att.net

Secretary, Newsletter Editor, Martin Grasmann

martin.grasmann@sbcglobal.net

This issue can be accessed in color on the website of the SAS!!!

http://sunsetastronomicalsociety.com

SAS Meeting

Start: 7:00 PM

Friday, May13th, 2011

Delta Planetarium

1. **Welcome, new members**

2. Evening's theme:

"Distant Starlight"

3. Club Stuff

Elections of SAS officers

What's up in the Sky

May 7-15 *Dawn:* Mercury less than 1.5 deg lower right of Venus, Jupiter can be seen also in same 5 deg field. Binoculars needed for Mercury!

May 10: 1st quarter Moon

May 11 *Dawn: Dawn:* Jupiter + Regulus ca 0.5 deg above and 1.5 deg below Venus.

May 13,14 *Evening:* Moon far to the lower right of Saturn on 13th and below Spica's lower right on 14th.

May 15-20 *Dawn:* Mercury in 1.5 deg vivinity of Venus. Faint Mars is less than 5 deg to their left.

May 17: Full Moon.

May 20,21 *Dawn*: Triangle formed by Venus, Mercury and Mars. Binoculars recommended!

May 22-24 *Dawn*: Watch out for Mars passing about 1 deg above of Venus on three mornings, Mercury can be found less than 4 deg to the left.

May 24: Last quarter Moon

May 29-31 *Dawn*: Waning crescent Moon to the upper left of Jupiter on the 29th, upper right of Venus on the 30th and then on the 31th crowded together with Venus and Mercury just above the pre-dawn horizon.

June 1: New Moon

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.

UPCOMING EVENTS