Sunset Astronomical Society

The Sunset Gazette

Serving the Tri-Cities since 1975

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Meeting information

Meetings are now at the Auburn City Hall, 113 East Elm Street in Auburn. 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.

New Membership Rates:

5$ per Year

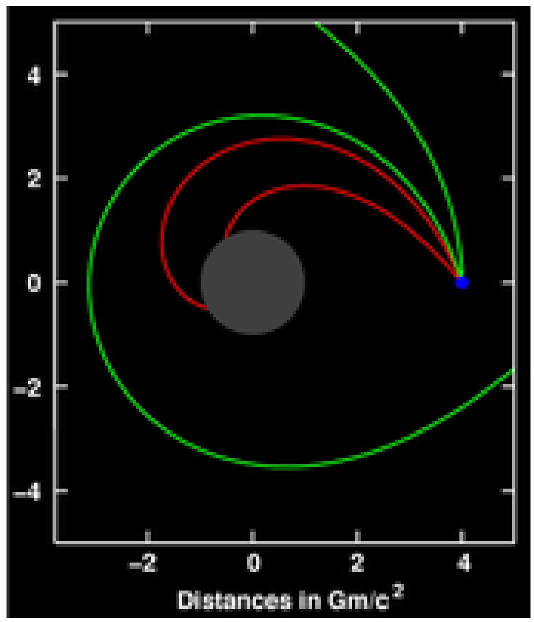
Treasurer's address for renewals and subscriptions:

Tom Smith, 3423 Hidden Road,

Bay City, MI 48706-1243

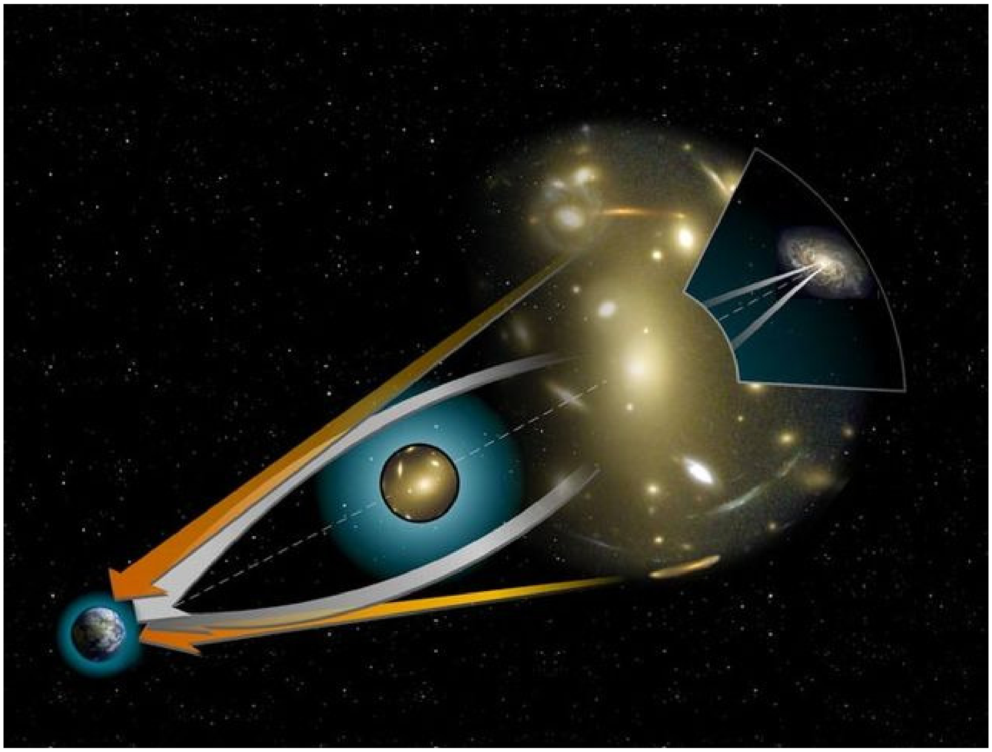
Gravitational Waves

At the begin of the 20th century Albert Einstein revolutionized physics and the common perceptions of space and time. In 1905 he laid the foundation for the four-dimensional space-time with his Special Theory of Relativity (x, y, z = three dimension for space and one for time) which later Herman Minkowski introduced in 1907. Then, in 1915 he postulated that mass and energy influence space and cause it to warp. In turn the warping of space then influences the movement of matter. This was the famous General Theory of Relativity. From this point on space-time was warped and dynamic and therefore very different from the Newtonian view in which space is static and has a flat geometry. For example the red-shift of the galaxies is not caused by the galaxies moving away from us through space at high speed, but rather it is space-time itself which is expanding and carrying the galaxies with it. Light transmitted by the galaxies is also stretched and shifted to the red part of the electromagnetic spectrum. Another consequence is that light is deflected in the vicinity of high mass objects like stars or black holes. To prove this one has to measure the position of stars close to the sun and without it. The best time to do this was during a total eclipse of the sun and in 1919 Arthur Eddington succeeded in doing exactly that. Despite the fact that Eddingtons's measurements were near the experimental limit of accuracy back then the confirmation of the light deflection by the sun was the first great triumph of the General Theory of Relativity. Another example is the gravitational lens effect in which a massive foreground object like a galaxy or galaxy cluster bends (or lenses) the light from the source lying far behind the foreground object. A gravitational lens is quite unlike a normal lens where the maximum bending occurs at the rim of the lens whereas in a gravitational lens the maximum bending occurs closest to the center. A gravitational lens therefore has no focal point but a focal line instead. If the observer, the foreground object (= lensing object) and the background object lie on a straight line the original light source will appear as a ring around the lensing object. Arcs would be sign of misalignment in which the foreground object is set off by some degree.



Deflection of light (sent out from the location shown in blue) near a compact

Many other predictions from the General Theory of Relativity have so far been confirmed like gravitational time dilation and frequency shift, orbital effects and the relativity of direction (Kepler problem),



Bending light around a massive object from a distant source. The orange arrows show the apparent position of the background source. The white arrows show the path of the light from the true position of the source. Source Wikipedia

orbital decay, geodetic precession and frame-dragging but one important prediction still lacks direct experimental proof: Gravitational waves.

Gravitational waves are generated when masses are accelerated: the change of the gravitational field propagates with light speed as an expansion and compression of space-time vertical to the direction of propagation. Try imaging a perfectly flat region of space-time with a group of motionless test particles lying in the paper plane. When a gravitational wave passes through the particles along a line perpendicular to the paper plane the particles will follow oscillating in a "cruciform" manner by following the distortion in space-time.

Sources of gravitational waves are all objects whose motions involves acceleration as long as the motion is not perfectly spherically symmetric like an expanding or contracting sphere, or cylindrically symmetric like a spinning disk or sphere. Think of a dumbbell : if it tumbles end over like two planets orbiting each other it will emit gravitational waves. If it spins like wheels on an axle it will not. Gravitational waves emitter include

- A planetoid which spins non-axissymmetric.
- A supernova except in the highly unlikely case the explosion is perfectly symmetric.
- Two orbiting stars, pulsars, black holes etc.
- A planet which orbits the Sun on a Kepler orbit (Earth, Mars, Jupiter etc).
- But a spherical pulsating star will not emit gravitational waves as will a non-spinning solid object moving at a constant velocity.

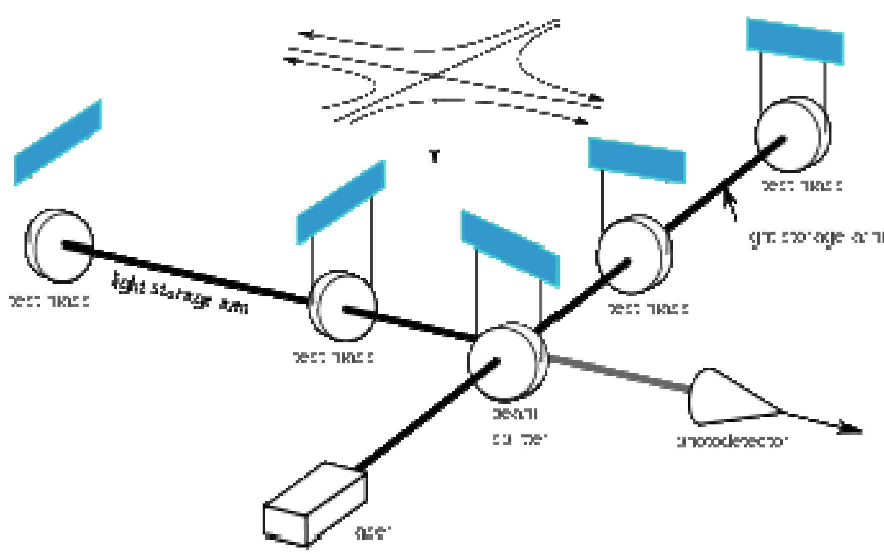
The indirect experimental proof has already been shown by the astronomers Russel A. Hulse and Joseph. H. Taylor which for many years observed the orbital decay of the binary double pulsar system 1913+16. The energy loss from the orbital decay matches exactly the value for the generation of gravitational waves predicted by the General Theory of Relativity. So even Earth on its orbit around the Sun will give off gravitational waves which reduces its energy and could eventually drop it into the Sun. But the emitted gravitational energy is tiny (200 watts), and daily decay is only about the diameter of a proton so it would take 10^{13} years! On the other hand the energy loss of the close binary pulsar system where each of the pulsar has about 1 solar mass and their distance is about 1/2 Earth-Moon distance is indeed quite dramatic. The gravitational radiation emitted by the pulsars would be 1.38×10^{28} watts, which is about 100 times more than the Sun's overall electromagnetic radiation.

But even Einstein was in doubt that gravitational waves would ever been detected directly due to the weak interaction of space-time and matter. Further, any gravitational wave signals arriving on Earth would be weekend by the enormous distance of the generating sources. For example a supernova explosion in the center of the milky way would generate a measurable change of only 1 attometer ($1\text{x}10^{-18}$ meter) over a distance of 1 km (0.65 miles) which is 1/1000 of the diameter of a proton! Nonetheless astronomers were always interested in detecting gravitational waves due their important and unique properties: gravitational waves can pass through intervening matter without being scattered significantly — unlike electromagnetic radiation which maybe blocked by interstellar dust. Also gravitational waves are generated by objects which otherwise would go undetected like binary uncharged black holes. Binary black holes or supernovae would generate gravitational waves in the low-frequency end of the gravitational-wave spectrum (10^{-7} to 10^{5} Hz). The high frequency end (above 10^{5} Hz and probably 10^{10} Hz) would be occupied by remnant of the Big Bang like the cosmic microwave background. In addition these high frequency gravitational waves may also be “man-made”.

Gravitational wave detectors: As mentioned the effect of a gravitational wave passing through matter is minute. In addition there is a massive amount of background noise present in the frequency range the current antennas operate. This background noise maybe man-made like traffic or by nature like tides, earthquakes etc. One of the first devices to measure gravitational wave motion is called a Weber bar - practically multiple stacked solid aluminum cylinders insulated from outside vibrations and equipped with piezoelectric sensors to measure the minute changes in length should a gravitational wave pass through it. Since 1968 Joseph Weber claimed to have detected gravitational waves on a daily basis but his results were strongly contested by other scientists. In 1987 he claimed to have detected the gravitational waves form the supernova SN 1987A in the Large Magellanic Cloud. Today modern variations of the Weber bar also called Resonant Mass Antennas are still operational with cryogenic cooling and equipped with superconducting quantum interference devices to detect vibration. In general Weber bars can only detect extremely powerful gravitational waves. One of these new devices is MiniGRAIL which uses a massive 2540 pounds cryogenically cooled sphere to detect gravitational waves. Based at Leiden University, Netherlands the sphere’s spherical configuration allows for equal sensitivity in all directions. The peak sensitivity is in the 3 kHz range making it suitable for detecting gravitational waves from rotating neutron star instabilities or small black hole mergers. Another smaller sphere is currently set up in in São Paulo, which will strongly increase the chances of detection by looking at coincidental events.

Laser interferometry is a technique which allows to build significant more sensitive detectors and all great gravitational wave detectors are now based on this technology. Here gravitational-wave induced motion between separated 'free' masses (see the test masses in picture below) are measured and because the masses can be separated by large distances the signal size is increased. A passing gravitational wave will slightly stretch one arm of the interferometer as it shortens the other. This is precisely the motion to which an interferometer is most sensitive. In addition the technique is sensitive to a wide range of frequencies - in the case of the Weber bars the frequency is determined by the Eigen-resonance of the bar. These ground-based interferometers are now operating in a network called the LIGO Virgo Science collaboration and includes the two LIGO interferometers in the USA, the VIRGO interferometer in Italy, the GEO600 interferometer in Germany and the CLIO interferometer in Japan. It is necessary to have as many detectors as possible and to spread them over the whole world to cancel out local disturbances, measuring errors and to look for coincidental signals . Only when several of the instruments detect a gravitational wave signal at the same time it can be deemed as real.

Continued in the next issue of the SAS newsletter!



A schematic diagram of a laser interferometer. Source Wikipedia

SUNSET ASTRONOMICAL SOCIETY
THE SUNSET GAZETTE
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This issue can be accessed in color on the website of the SAS!!!

http://www.sunsetastronomicalsociety.com

SAS Meeting

Start: 7:00 PM

Friday July 11th, 2014

(If not otherwise announced by e-mail)

Auburn City Hall

113 East Elm Street Auburn

Welcome members and guests

New and old business

Club Business

Treasure report

Refreshments Break

Presentation: TBD

What's up in the Sky

July 3: Earth is at aphelion, its farthest position from the Sun.

July 3,4 *Evening*: The dwarf planet Ceres (7.0 mag) and planetoid Vesta (5.8 mag) are only 10' apart. See finder chart below. Binoculars needed!

July 5 *Evening*: Watch out for Mars very close to half lit Moon.

July 5: First Quarter Moon

July 7 *Evening*: Watch out for Saturn very close to the waxing gibbous Moon.

July 12-24 *Dawn*: Mars shines 6-8 deg to the lower left of Venus.

July 12: Full Moon

July 13 *Evening*: Mars shines 1.3 eg north of Spica.

July 18: Last Quarter Moon

July 22 *Dawn*: Waning Moon very close to Aldebaran.

July 24 *Dawn*: Crescent Moon ca 5 deg right of Venus. Also look out for Mercury to their lower left.

July 25 *Dawn*: **Look out for a very A thin** crescent Moon below Venus and to the lower right of Mercury ca 45 min before sunrise east-northeast.

July 26: New Moon

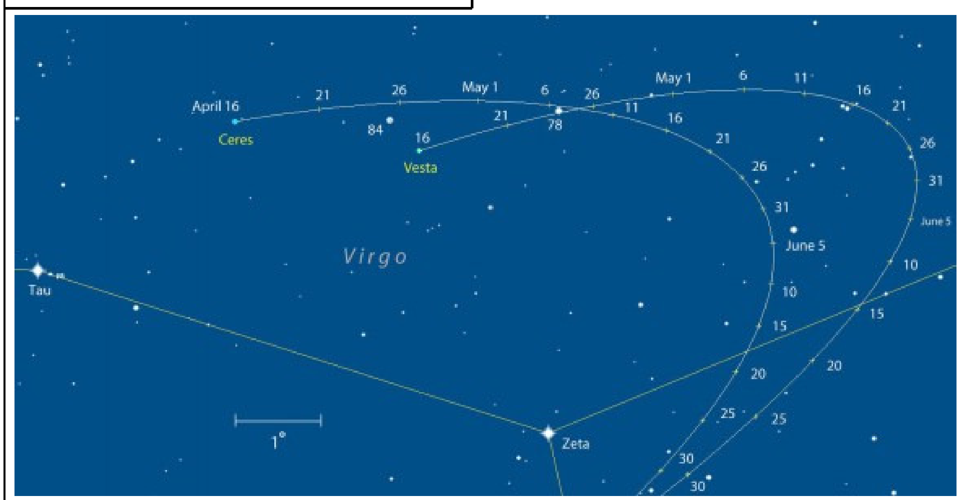
July 28 *Night*: Delta-Aquarid meteor shower peaks around this date.

August 2 *Dusk*: Mars shines 5 deg to the left of waxing crescent Moon.

August 3: First Quarter Moon

August 3 *Dusk*: 1st quarter Moon between Mars and Saturn.

August 10: Largest full Moon of the year!



From Universe Today: http://www.universetoday.com/111280/ceres-and-vesta-converge-in-virgo-watch-it-happen-with-just-binoculars/