Sunset Astronomical Society

The Sunset *Gazette*

Serving the Tri-Cities since 1975

Volume 11, Issue 12

August 2014

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:

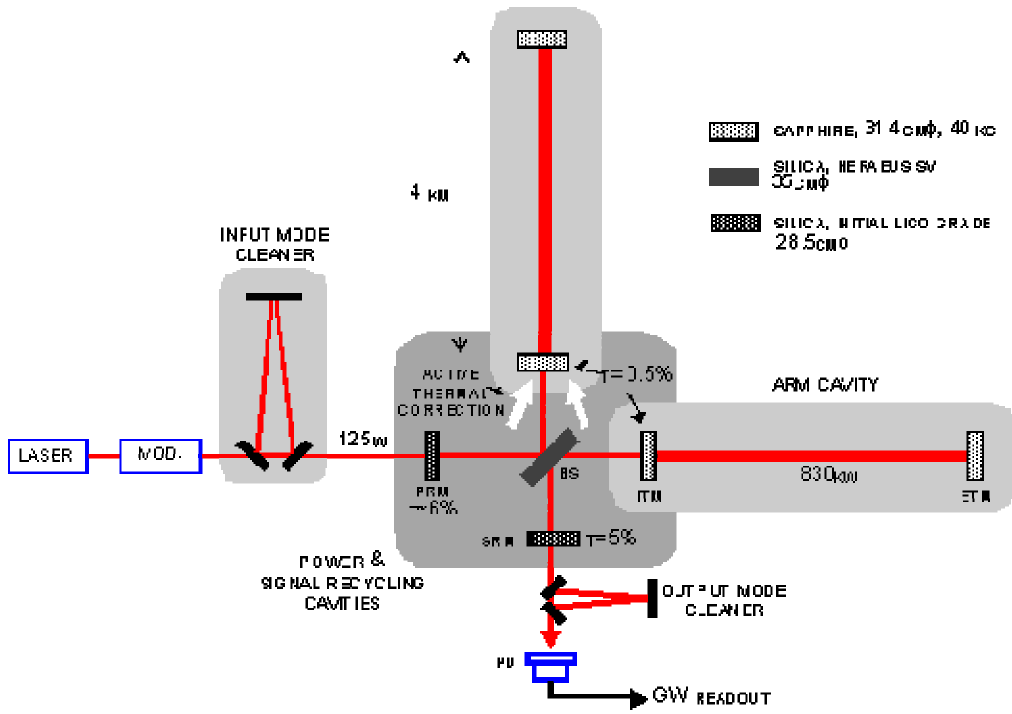
Tom Smith, 3423 Hidden Road,

Bay City, MI 48706-1243

Gravitational Waves

Second part and continuation of the **Gravitational Wave** series started in the last SAS newsletter. In the last issue we have spoken about detectors for gravitational waves and we will continue talking about laser interferometers which are now considered as best tool to detect these elusive waves. As mentioned these 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. This close international cooperation has a twofold aim: First a technology transfer between the experiments to steadily increase the sensitivity of the instruments. A central role plays the GEO600 situated in Ruthe near Hannover in Germany and run by a collaboration between German and British institutes. While GEO600 has the smallest interferometer measuring distance of all instruments (600 m) and therefore also the lowest measuring precision, the interferometer became somewhat of a test bed for new technologies which are then transferred to the much larger LIGO interferometers in the US and the rest of the world. For example the three LIGO detectors in the US, one in Livingston, Louisiana and two in Hanford, Washington (within the same experiment) have a measuring distance of 2000 respectively 4000 m! The VIRGO detector, a joint collaboration between Italy and France near Pisa, Italy has a measuring distance of 3000 m. Apart from the technological exchange a second reason is the fact that you need three detectors in three separate places to determine the direction of a source, and three detectors are also needed to determine the spatial orientation = polarization of a gravitational wave. Additional the further apart the detectors, the higher the spatial resolution of a measurement and the increse in sensitivity.

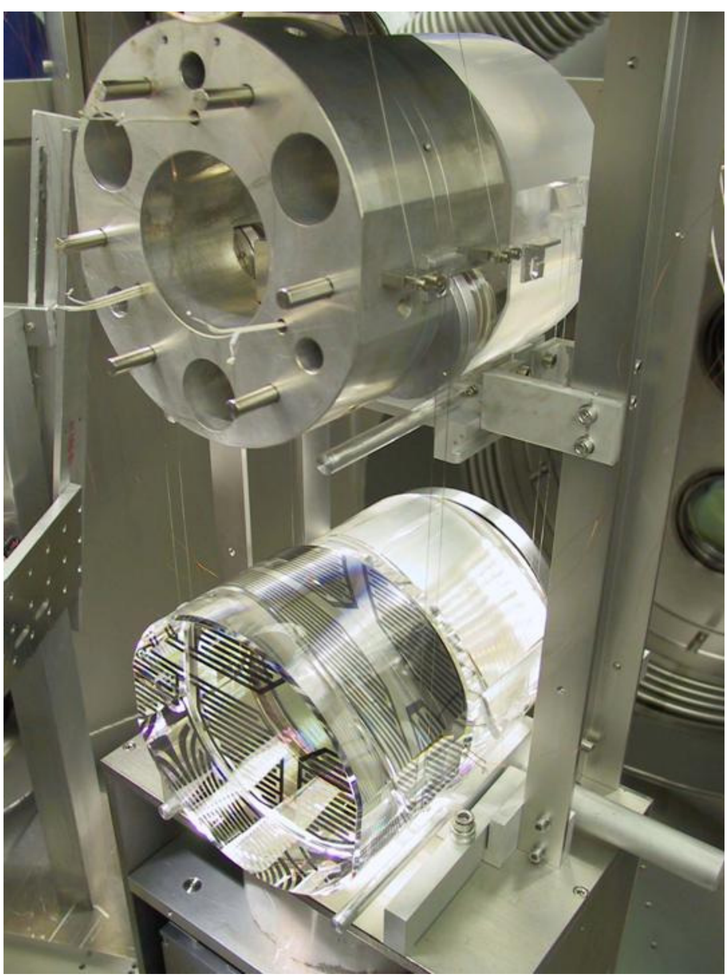
See picture below: Aerial view of the LIGO-Detector in Hanford, WA.



Advanced LIGO with representative mirror reflectivities optimized for neutron star binary inspiral detection. Several new features compared to initial LIGO are shown: more massive, sapphire test masses; 20´ higher input laser power; signal recycling; active correction of thermal lensing; an output mode cleaner. (ETM = end test mass; ITM = input test mass; PRM = power recycling mirror; SRM = signal recycling mirror; BS = 50/50 beam splitter; PD = photodetector; MOD = phase modulation). Mode-matching and beam-coupling telescopes not shown. Picture: http://www.ligo.caltech.edu/a

All gravitational wave detector work according to the principles of a Michelson interferometer (see left a schematic of the Advanced LIGO interferometer). The infrared laser light originating on the left hits a beam splitter (BS, center of the schematic) and is then split in two beams of equal intensity and directed along the two arms of the interferometer. At the end of each arm two mirrors reflect the beams back to the beam splitter where they converge and interfere. This signal beam is then directed to the photo detector (PD, blue) which measures its intensity. Because of the wave nature of light a signal is increased in strength when the two beams converge with the same phase or the signal is eliminated when the phase is shifted by 1/2 wave length. If the distance which both beams have to travel changes in relation to each other, e.g. a gravitational wave passes by and stretches or compresses the interferometer arms unevenly, then the relative phase of both beams also changes which can be measured as intensity variation at the photo detector.

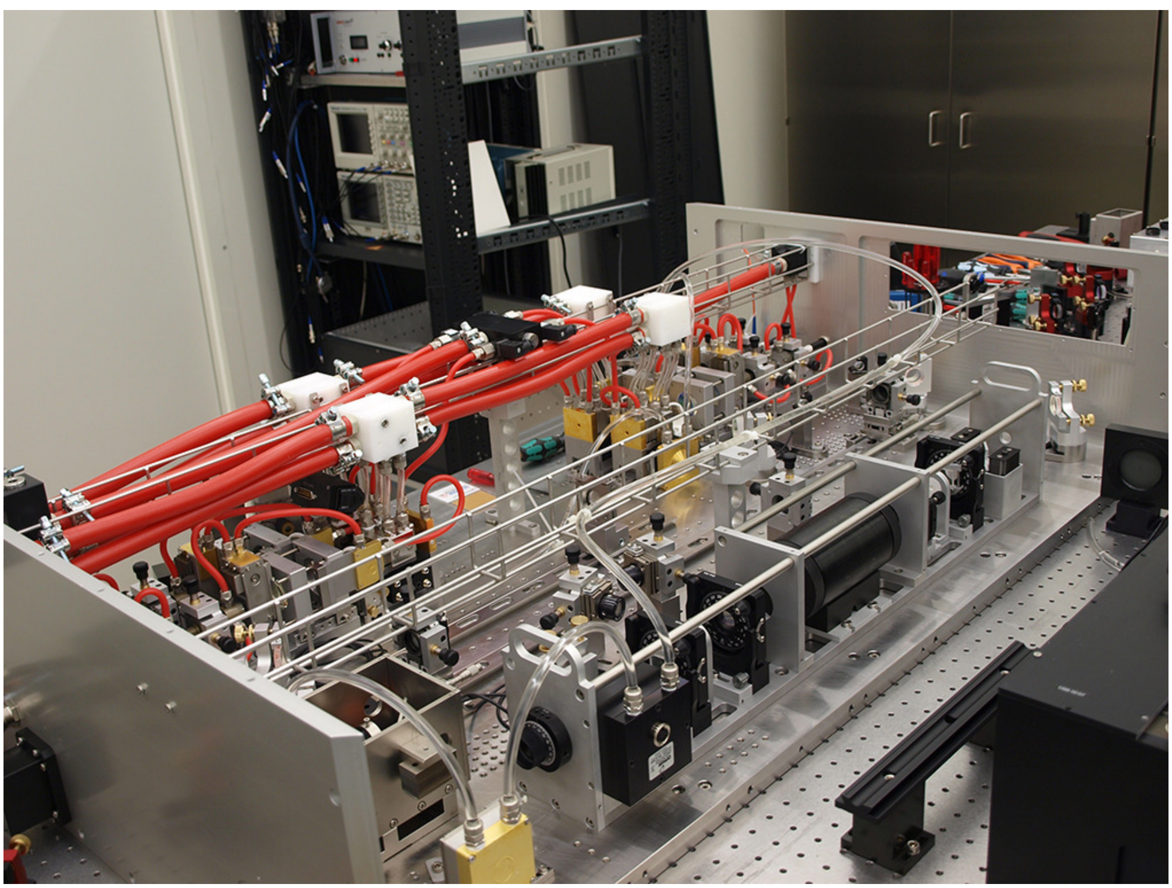
Unfortunately such intensity variations can be caused not only by gravitational waves but all kinds of other seismic more earthly phenomena. The ground based interferometer are most sensitive for gravitational waves between 10s to 1000 Hertz frequencies and especially the range below 100 Hz things like



Mirrors for GEO600: On top you see the pendulum counter mass and suspended from it the quartz cylinder which acts as the mirror. If you look carefully you can see the quartz fibers holding the mirror. Source http://www.2physics.com/2011/09/gravitational-wave-observatory.html a passing cars and even walking pedestrians on the research facility can produce positive signals. These signals are huge compared to the expected gravitational wave signals, e.g. the GEO600 can even measure the surf of the not so far away North Sea. To eliminate seismic interferences scientists of the University of Glasgow constructed a special multiple pendulum system to dampen external vibration by 9 orders of magnitude. Hereby the 10 kg weighing mirrors are suspended as pendulums to isolate them from various disturbances. The suspension itself of course has to be able to hold the mirrors and not to cause disturbances of their own. The suspension itself are fibers made out of thin threads of quartz which have far less internal losses than equivalent steel wires. The fibers are bonded directly to the mirrors and a second pendulum mass, by this way no friction will occur at the point of contact (see picture on the lower left on previous page). In addition, electromagnetic or electrostatic actuators drive the individual components of the pendulum to further reduce the residual noise. The system is so effective that to jolt the gravitational wave detector out of alignment you would need an earthquake of 6 or above on the Richter scale occurring anywhere in the world.

Another important factor is the stability of the high powered lasers used in the gravitational wave experiments. When laser light hits the beam splitter and mirrors the impulse of the photons actually generate a tiny pressure which in turn changes the lengths of the measuring distances relative to each other: one arm of the instrument gets shorter, the other one longer. If the laser light would be absolutely constant the intensity of the effect (= the difference in distance) would be of the same constant, too. Unfortunately laser light undergoes natural intensity variations and the noise generated by the signal beam is of the same order than a potential gravitational wave event. On the other hand if more photons hit the beam splitter and mirrors per time units the variations are evened out and become less important. Therefore a continuous high power laser system was needed. GEO600 developed a laser system with 200 W output exceeding the original laser by a factor of 20. The laser has the additional feature that its output is also very stable in terms of its wavelength at 1064 nanometers. The first units of this new laser system are now also deployed in the Advanced LIGO detectors in Hanford and Livingstone. To make optimal use of the laser intensity the light is actually recycled which is achieved by an additional mirror transforming the interferometer into a resonator for the laser beam. The captured laser beam is run several times through the interferometer and is superimposed with the newly fed in laser light. This trick lets GEO600 increase the laser intensity to about 3000 W and is also used at the LIGO and VIRGO interferometers.

Insight into the den 200-Watt-laser oscillator for LIGO Source: http://www.aei.mpg.de/283265/Wertvolle_Fracht_auf_hoher_See



Continued in the next issue of the SAS newsletter!

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

Martin Grasmann **martin.grasmann@sbcglobal.net**
Newsletter Editor

Elected Officers for the SAS:

President - Ed Borus **etbjr@chartermi.net**

Vice President / Activities - Axel Mellinger

Secretary - Mohammad Khan **khan001@charter.net**

Treasurer - Thomas Smith **tom258@att.net**

Advisor - Garry Beckstrom **garry@beckstromobservatory.com**

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

http://www.sunsetastronomicalsociety.com

SAS Meeting

Start: 7:00 PM

Friday Aug 8th, 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

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!

August 12-13 *Late Night to Dawn***:** Peak of the Perseid Shower. Waning gibbous Moon interferes with the faintest meteors.

August 17: Last Quarter Moon

August 18 *Dawn***:** Venus and Jupiter are 0.2 deg apart at 5h UT. They will still be 0.5 deg apart when both rise in the Americas.

August 18 *Dawn***:** Waxing crescent Moon forms triangle with Venus and Jupiter.

August 23-26 *Dusk***:** Mars passes 3.5 deg south of Saturn.

August 26: New Moon

August 31 *Dusk***:** Moon forms tight triangle with Mars and Saturn.

Sep 2: First Quarter Moon

Sep 5 *Dawn***:** Regulus shines to ca 1 deg to the lower right of Venus low in the east about half a hour before sunrise.