Sunset Astronomical Society

The Sunset *Gazette*

Serving the Tri-Cities since 1975

Volume 12, Issue 2

October 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

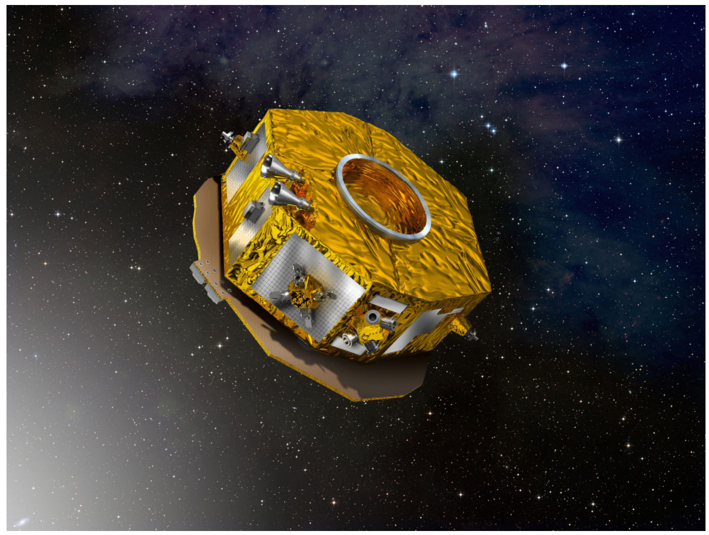
Treasurer's address for renewals and subscriptions:

Tom Smith, 3423 Hidden Road,

Bay City, MI 48706-1243

Gravitational Waves

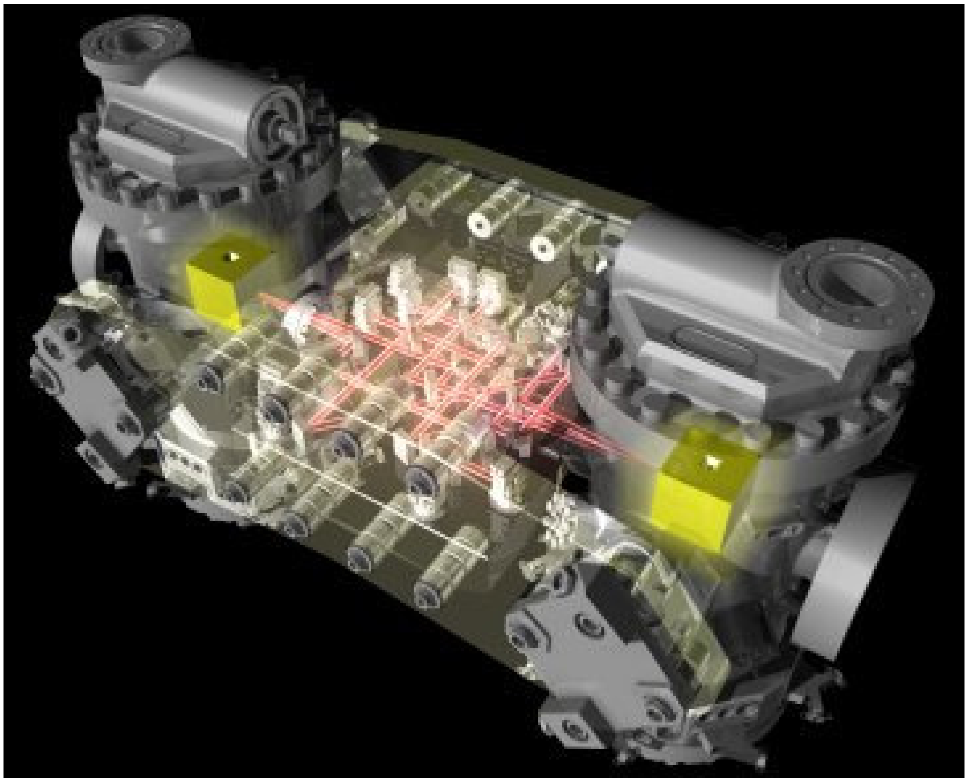
Fourth part and final part of the **Gravitational Wave** series started three SAS newsletters ago. In the previous newsletters we covered ground based detectors for gravitational waves and spoke about **eLISA**, a future space based laser interferometer. It will consist of three satellites flown in a nearly equilateral triangular configuration with a base length between 600000 to 1800000 miles and its center of gravity would follow the Earth on its journey around the Sun in a slowly increasing distance of 15 to 38 million miles. The proposed launch is still some time in the future (2034) giving the engineers hopefully ample of time to iron out the great technical challenges which come with this mission.



LISA Pathfinder: Its position will be controlled by the Disturbance Reduction System (DRS) developed by the Jet Propulsion Laboratory and includes micro rockets which keep the spacecraft position within a millionth of a millimeter. Source: http://www.esa.int/spaceinimages/Images/2013/11/Artist_s_impression_of_LISA_Pathfinder2

To test some of the technologies ESA has devised a pathfinder mission for 2015 which serves as a test bed so engineers and scientist can study and test components and systems under a real space environment. The satellite which carries the instruments will be placed in a halo orbit around the Lagrange point L1 which lies on the Earth-Sun line approximately 1 million miles towards the Sun and also serves as a prime observing spot for various solar observing satellites.

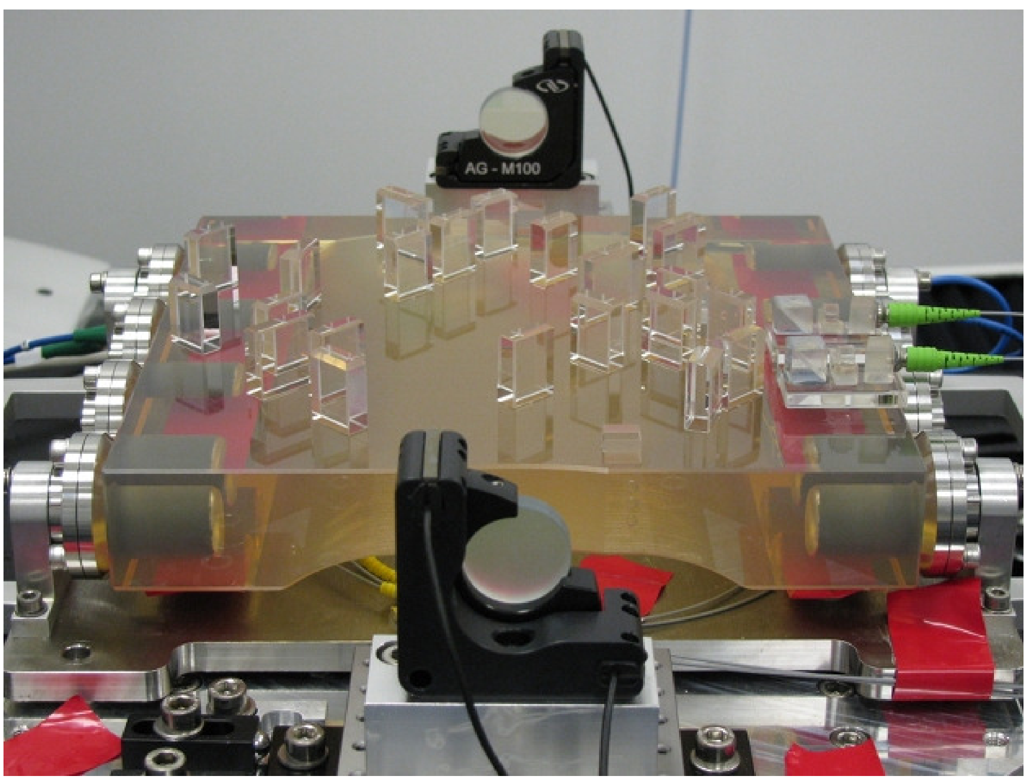
The **LISA** pathfinder will simulate one arm of the **eLISA** interferometer but will be shortened to about 14 inches instead of 600000 to 1800000 miles. The core experiment are two test masses made of a gold-platinum alloy which will freely float in vacuum chambers during the test period. Between the two cubes sits the optical bench with a multiple redundant laser interferometer. It measures the position and spatial torsion of the test masses in relation to the satellite and the position and orientation of the two test cubes. During the experiment a laser is coupled into the optical bench and divided by a beam splitter into the different measuring branches. Two of the laser beams will be directed at the free floating test cubes through windows in the vacuum chambers. From there both beams will be reflected back into the optical bench and cause interference. The variation in intensity o the



LISA Technology Package (LTP): This is one of two technology test packages to fly onboard LISA Pathfinder. The yellow cubes are the free floating test masses consisting of 46 mm gold/platinum alloy cubes. The cubes serve both as mirrors for the laser interferometer (red lines depict the light path) and as inertial references for the drag-free control system of the spacecraft. Source giotto.esa.int/science-e/www/object/index.cfm?fobjectid=42235

Interference pattern will then allow to determine the phase shift between both laser beams. The maximum measurable phase shift is about 1/100000 of the laser wave length. These minute changes allow the scientist to derive the position of both test masses.

In addition to the interferometer measurements there are capacitive inertial sensors which measure the position of both cubes about 10 times per second. This measurement is not as precise but the data is send to the Drag-free Attitude Control System which regulates the propulsion engines which keep the pathfinder module always centered in relation to the test masses. You can imagine that the propulsion engines have to be incredible sensitive and deliver a tiny trust between 100 micro Newton to 1 Newton with a precision of 0.1 micro Newton. Two sets of different position control thrusters are on board of the LISA pathfinder and both are none-chemical. For both propulsion units the



LISA Pathfinder flight optical bench: On top of the bench you see the glass components ("tombstones") who are precision bonded to the optical bench. The bench itself is a 8"x8" block of Zerodur ceramic glass. The two laser beams arrive into the optical bench through the glass fiber optic (green connectors). This light is then reflected and/or split by the "tombstones". One beam will reflect off the two mirrors to the front and the back of the optical bench that are being used to represent the free-falling test masses. The other beam stays within the bench. Source: sci.esa.int/lisa-pathfinder/ 51960-lisa-pathfinder-flight-optical-bench-during-construction/.

LISA Pathfinder is a technology test bed and the thrusters are slated for other future space missions like the ONERA Microscope Mission which will test the Equivalence Principle with a precision of 10^{-15}, about 100 times more precise than possible on Earth (the Equivalence Principle states that "The trajectory of a falling test body depends only on its initial position and velocity, and is independent of its composition"). Each of the propulsion units will be integrated in four single thrusters: The Jet Propulsion Laboratory will contribute two aggregates with colloid thrusters which are based on the electrostatic acceleration of fine droplets of tributylphosphate. ESA will contribute four cold gas micro thrusters which have already been tested on the 2013 launched astrometry satellite GAIA. The cold gas thruster rely on nitrogen gas which is ejected under high pressure and low flow in a very uniformly manner to maintain an even thrust.

One problem which **LISA** will encounter during the mission is the electrostatic charging of the test masses and the vacuum chambers through cosmic rays and electrical stray fields of the metal surfaces in the vicinity. To dissipate the charge the test masses and the chamber are irradiated with UV light. This causes a photoelectric effect during which photo electrons are released from the material which in turn is charged positively. This compensates the original charging of the test masses and reduces the electrostatic and electromagnetic disturbing forces.

What makes this mission so complicated is that the LTP (Lisa Technology Package) can not be seen as an independent unit from the rest of the satellite and even very small changes of the subsystems can have negative consequences on the extreme technical requirements of the mission. Hence a very complex computer simulation was used to get a better understanding of all the interactions between the different parts of the satellite and the LTP. This also generated a detailed mass and gravitational model which specified the mass distribution of the probe down to milligrams. Then of course there are the components of the LTP itself which interact with each other: Examples are the capacitive inertial sensors, electrostatic or magnetic field fluctuations on board or the interplanetary magnetic field, thermal effects caused by temperature variations in the residual gas around the test masses, and variation in the power of laser beam which leads to a variation in the radiation pressure on the test masses.

LISA pathfinder will be launched in the second half of 2015 by a Vega rocket from the European space center in Kourou, French Guiana. From an elliptical park orbit around Earth the probe will be lifted into higher and higher elliptical orbits by consecutive firing of its orbital thrusters and finally into a transfer orbit to the Lagrange point L1. After 40 days the probe will enter a halo orbit around L1 and jettison its main propulsion unit. The halo orbit around L1 will keep the **LISA** pathfinder in position with minimal use of propellant. There are two measuring campaigns planned which should verify the mission goals: A) Demonstration of the drag-free and attitude control of the spacecraft with two test masses in order to isolate the masses from inertial disturbances. B) Demonstration of the feasibility of performing laser interferometry in the required low-frequency regime with a performance as close as possible to 10^{-12} m $Hz^{-1/2}$ in the frequency band 1-30 mHz, as required for the **eLISA** mission. And finally C) Assessment of the longevity and reliability of the capacitive sensors, thrusters, lasers and optics in the space environment. If the mission can be extended **LISA** pathfinder is in excellent position to answer the question if the gravitational force deviates from the Newtonian Theory of Gravity as is postulated by the theory of Modified Newtonian Dynamic (MOND).

There is still 20 years to the launch of **eLISA** and about 10 years before construction begins in earnest. Hopefully this is enough time to further develop components like an extremely stable laser system with 2 W power output and other mission critical systems. If successful the mission will open a window into the universe of gravitational waves which until now is completely closed. Earth based gravitational wave research will of course have a huge impact on the mission. So far no gravitational waves have been detected without doubt all hopes are on the next round of upgrades to the big interferometers like LIGO or VIRGO. These instruments should reach their full capacity in the next 1-2 years and start looking for these elusive waves in earnest. If despite these efforts no gravitational waves are detected questions will of course be asked: Is our technology still not advanced enough or is there a some fundamental yet still unknown reason why they are not detectable.

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

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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: 6:00 PM

Saturday Oct 11th, 2014

Please check your e-mail regarding new date, time and place!

Delta Planetarium

Bay City

Call to Order + Introduction of Guests

Election of club officers (president, vice president, treasurer, secretary) **(Any update from the search committee on volunteers for these positions?)**

Future club meetings: Date, time (I suggest to have the spring 2015 meetings on the 1st Saturday of the month to avoid conflicts with Messier Marathon dates around new moon)
Topics: We need volunteers for presentations! *Break*

Workshop: Time-lapse photography (Axel Mellinger). Bring your cameras!

Partial Solar Eclipse on Oct. 23 (any joint activity with Delta Planetarium?)

Other topics

Adjournment

What's up in the Sky

Sep 21 - Oct 6 *Dawn*: The Zodiac light is visible 120 to 80 minutes before sunrise. Look out for a huge pyramid of light stretching up to Jupiter. Dark locations needed!

Oct 8 *Predawn*: **Total Eclipse of the Moon (see below)**

Oct 8: Full Moon

Oct 17, 18 *Dawn*: Moon shines to upper right of Jupiter on 17th and right of Jupiter on the 18th.

Oct 15: Last Quarter Moon

Oct 19 : Nightfall: Comet C/2013 Siding Springs passes very close to Mars.

Oct 20—22 *Predawn*: Orionid shower active shortly before first light.

Oct 20 - Nov 4 *Dawn*: The Zodiac light is visible 120 to 80 minutes before sunrise. Look out for a huge pyramid of light stretching up to Jupiter. Dark locations needed!

Oct 23 Afternoon/Sunset: **Partial Eclipse of the Sun**

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Oct 23 Afternoon/Sunset: **Partial Eclipse of the Sun**

Oct 25 *Dusk*: Saturn visible to the lower right of thin crescent Moon low in the west-southwest half an hour after sunset.

UPCOMING EVENTS

Astronomy Day

SATURDAY, OCTOBER 4th

Delta Planetarium, Bay City

Astronomy Day is an international event designed to share the joy and excitement of astronomy with those who may never have had a chance to look through a telescope at our Sun, Moon, Planets, or Deep-Sky Objects. The Delta College Planetarium offers special shows & events during **Astronomy Day.**

3 pm: "Perfect Little Planet" - NEW Solar System Show
4 - 5 pm ROCKET RALLY - Featuring Space Racers

7 pm: "Stars" Planetarium Show
8 - 9:30 pm: Using Smart Phones as Sky Maps

Local times for Lunar Eclipse in Detroit on Wednesday, October 8, 2014

Event	Time in Detroit	Altitude	Comments
Penumbral Eclipse begins	Oct 8 at 4:17 AM	34.4°	The Earth's penumbra starts touching the Moon's face.
Partial Eclipse begins	Oct 8 at 5:18 AM	24.5°	Partial moon eclipse starts - moon is getting red.
Total Eclipse begins	Oct 8 at 6:27 AM	12.5°	Total moon eclipse starts - completely red moon.
Maximum Eclipse	Oct 8 at 6:55 AM	7.6°	Moon is closest to the center of the shadow. Moon close to horizon, so make sure you have free sight to West.
Total Eclipse ends	Oct 8 at 7:22 AM	2.9°	Total moon eclipse ends. Moon close to horizon, so make sure you have free sight to West.
Moonset	Oct 8 at 7:41 AM	0.0° below	Below horizon