Press release

CSEM tests key equipment for the LISA gravitational wave space observatory

Switzerland, 14 September 2021 – CSEM (Switzerland) is testing a special laser developed by NASA for the Laser Interferometer Space Antenna (LISA) mission. Led by the European Space Agency (ESA), LISA aims to detect gravitational waves in space and obtain fresh insight into the structure of black holes and the origin of the universe. The three spacecraft involved in the mission are scheduled to launch in 2034.

Gravitational waves contain crucial information about the history and structure of our universe. They are produced during major astrophysics events – like collisions and mergers of black holes – so powerful that they create distortions, or waves, in spacetime. Albert Einstein theorized the existence of gravitational waves over a century ago, and astrophysicists now intend to measure them to better understand the origin of our universe (the Big Bang), as well as the black holes, stars, and galaxies it is made of.

Gravitational waves were detected for the first time on Earth in 2015 by two large interferometer gravitational-wave observatories (see box). However, the scope for research was limited by both the size of the instrument and ground interference.

The LISA mission will overcome these obstacles by measuring gravitational waves directly in space. It will use three spacecraft arranged in the form of an equilateral triangle with 2.5 million kilometer sides – making the interferometer several hundred times bigger than Earth. As the first space mission designed to detect gravitational waves, LISA will open the door to a whole new field of research. For instance, by combining data collected from gravitational waves with those from electromagnetic waves (like X-rays, UV and IR waves, as well as light and radio waves), physicists will be able to identify and characterize cosmic events in completely new ways.

ESA is working closely with international partners including NASA, which has developed a custom infrared laser for this mission that pushes the boundaries of state-of-the art technology in terms of stability (See NASA PR). CSEM has been selected by ESA to provide expert metrology support to the LISA mission due to its solid experience in space research and extensive know-how in ultra-stable lasers. Its role will include testing the stability of the NASA lasers' frequency and power to make sure they meet the demanding specifications of the LISA mission.

"We set up an underground lab specifically for LISA in order to minimize outside interference like vibration and temperature variation," says Lauriane Karlen, an engineer at CSEM. "We plan to compare the frequency stability of NASA's laser with that of our benchmark lasers, which are cavity-stabilized." This testing step will be crucial since the gravitational waves' signals are extremely small. Once set up in space, LISA will have to detect movements on the order of a picometer (smaller than an atom) over a distance of 2.5 million kilometers. The mission will succeed only if its instruments are exceptionally accurate and its lasers, which are key in the measurement, are ultra-stable.

"NASA has made remarkable progress in developing an extremely stable engineering model laser system that will enable breakthrough space-based gravitational wave science measurements. We anticipate that the testing and analysis to be done at CSEM will result in opportunities to further improve the model", says Terence Doiron, NASA LISA Study Manager.

Mission plan

LISA is scheduled to be launched in 2034. Its three spacecraft will follow the Earth around the sun, trailing it by some 50 million kilometers. Each spacecraft will simultaneously send and receive laser beams to and from the others. Because gravitational waves distort spacetime, masses that are floating freely inside the spacecraft will shift in position by tiny amounts as a wave passes by. These changes in distance are what the LISA instruments will detect and measure.

"If successful, LISA will considerably expand our knowledge in the field of astrophysics," says Fabien Droz, head of instrumentation at CSEM. "It will let us observe the first moments of cataclysmic phenomena occurring in our universe. We're honored to take part in this major mission."

Press Kit (pictures / video) : LISA Mission

Gravitational waves are key elements of Einstein's general theory of relativity, which states that all accelerating bodies create these waves as a function of their mass. Unlike electromagnetic waves, such as light and radio, gravitational waves are hardly influenced by matter, meaning they can travel undisturbed for long distances. Another research benefit of gravitational waves is that they can be used to study cosmic objects that do not emit electromagnetic waves, like black holes.

These waves were detected for the first time on Earth in 2015 at the LIGO observatories. The discovery, made simultaneously by the two stations located thousands of kilometers apart, indicates that the waves were generated some 1.3 billion years ago when two black holes merged.

The 2017 Nobel Prize in Physics was awarded to three physicists for their pioneering work in the experimental observation of gravitational waves.

LISA aims to answer some key questions in astrophysics

For example:

Supermassive black holes
When did the first black holes form? What is the mechanism of black hole formation in galactic nuclei? How do black holes evolve over cosmic time?

Gravity
What is the nature of gravity? How does gravitational information propagate? What is the structure of spacetime? Does spacetime contain horizons?

Binary stars
How is the Milky Way structured? How many ultracompact binary stars exist in the Milky Way?

The origin of the universe

LISA will study three main periods of evolution in cosmic history: the cosmic dawn, when the universe was only a few hundred million years old and the first stars, black holes and galactic discs began to form; the cosmic "high noon," which is a period of critical transformation for galaxies when star formation peaked; and the cosmic afternoon, our present time of declining star formation and slowing evolution.

Learn more about LISA on:

The LISA website
The ESA website
The NASA website

Press Kit (pictures / video) : LISA Mission

Additional information

CSEM

Lauriane Karlen
R&D Engineer
Tel. +41 32 720 52 94
E-mail: lauriane.karlen@csem.ch

Fabien Droz
Head of Instrumentation Activity
Tel. +41 32 720 59 73 / +4178 808 63 96
Email : fabien.droz@csem.ch

CSEM – Media

Laure-Anne Pessina
Strategic Communication Manager
Tel. +41 32 720 5226
Mobile: +41 79 360 25 38
Email: laure-anne.pessina@csem.ch

About CSEM

CSEM—technologies that make the difference.

CSEM is a Swiss research and development center active in the fields of precision microfabrication, digitalization, and renewable energy. CSEM builds up the ties between industry and academia. It supports companies as a hub of ingenuity, a center of technological excellence and innovation, and accelerator of the digital transformation.

Further information is available at www.csem.ch Follow us on: