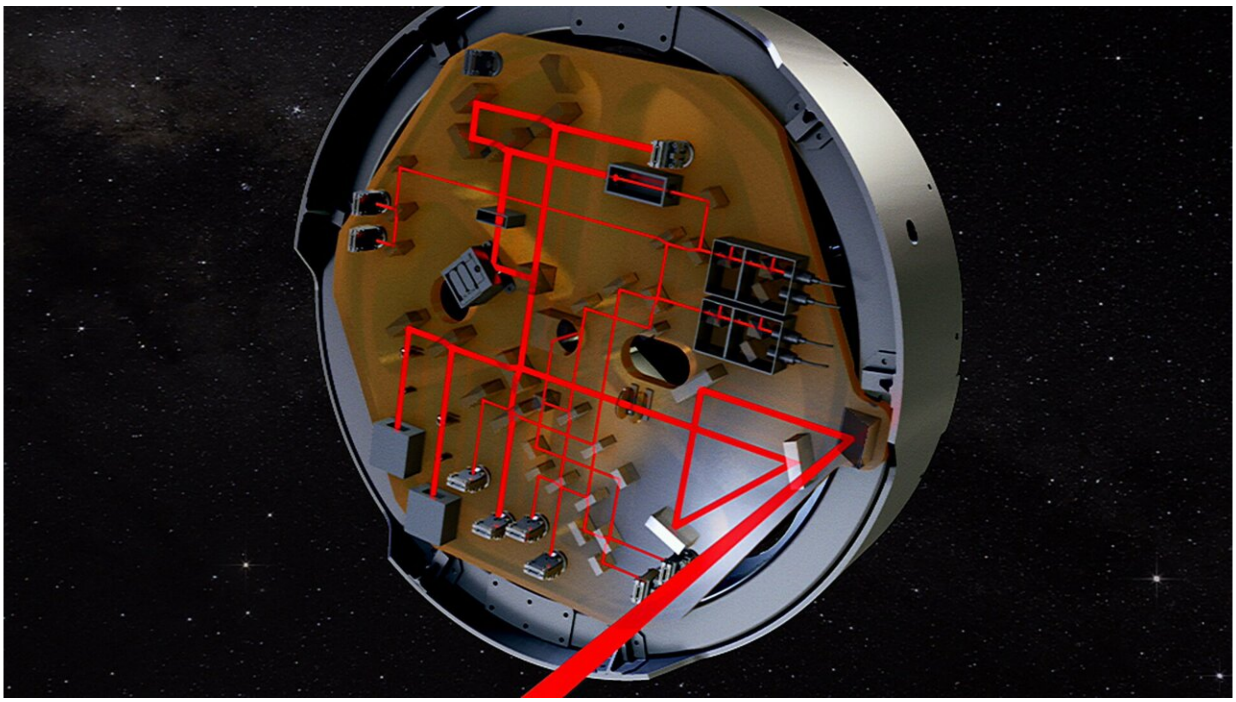
ESA gives go-ahead for flagship gravitational-wave observatory in space

January 25 2024



Artist's impression of LISA's optical bench interferometer. Credit: AEI/MM/exozet

LISA, the Laser Interferometer Space Antenna, has passed a major review: the entire concept—from the definition of the overall mission and operations to the space hardware to be built—stood up to the intense scrutiny of ESA's reviewers.

Now the space agency's Science Program Committee (SPC) has confirmed that LISA is sufficiently mature and that mission development can proceed as planned. LISA should go into orbit in the mid 2030s.

Karsten Danzmann, Lead of the LISA Consortium, Max Planck Institute for Gravitational Physics and Leibniz University Hannover, said, "With the Adoption decision, LISA is now firmly established in ESA's program of missions. We are looking forward to realizing LISA in a close collaboration of ESA, NASA, ESA member states and the wider LISA Consortium."

Carole Mundell, ESA Director of Science, said, "This trailblazing mission will take us to the next level in a really exciting area of space science and keep European scientists at the forefront of gravitational wave research."

LISA's successful Mission Adoption Review and the adoption by ESA's Science Program Committee on January 25 was the formal end of the study phase. LISA will now transition into the implementation phase.

The UK has a major involvement in the LISA mission, with significant contributions to the instrument hardware and the on-ground data processing and analysis. The UK Space Agency (UKSA) has agreed participation in the mission in principle.

The UK Astronomy Technology Center (UK ATC), in collaboration with the University of Glasgow, leads the UK's hardware contribution to LISA—the design and construction of the ultra-precision optical benches that sit at the heart of each LISA spacecraft.

The optical benches send and receive laser beams between the LISA spacecraft and combine them together to produce signals that contain the signatures of gravitational waves, and the UK team has developed an innovative robotic system to assist in their construction.

Their work will build on the University of Glasgow-led design and build of the optical bench for the LISA Pathfinder mission, which was launched into space in 2015 to test the technology ahead of the full LISA mission. The success of LISA Pathfinder, which performed beyond expectations, helped pave the way for the completion of the Mission Adoption Review.

Ewan Fitzsimons, principal investigator for the UK hardware contribution to LISA at UK ATC said, "The adoption of LISA is a very exciting moment for us, and it's fantastic to see the mission move to the implementation phase, bringing us one step closer to launch. The unique robotic integration technology our team have developed has transformed our capability to construct the optical benches crucial for deciphering the secrets of gravitational waves in space."

Prof Harry Ward, of the University of Glasgow's School of Physics & Astronomy, led the development of the optical bench for LISA Pathfinder, which won the Glasgow team the 2016 Sir Arthur Clarke award for Space Achievement in Academic Study/Research. He has played a key role in developing the UK's planned contribution to LISA.

He said, "I'm delighted that the decades of research and development work on LISA and LISA Pathfinder carried out here in the UK, across Europe and in the US has resulted in the crucial milestone of mission adoption.

"The LISA mission will open up an exciting new opportunity to detect gravitational waves in space that would be impossible to detect here on Earth, allowing us to learn more about previously hidden aspects of the universe. I look forward to the LISA team in the University's Institute for Gravitational Research playing an important role in the construction of the optical systems that will be at the heart of LISA."

Scientists at the University of Birmingham, University of Glasgow, University of Portsmouth, University of Southampton and University of Cambridge are working on addressing important challenges in LISA data analysis and simulation as part of the LISA Science Ground Segment.

As a first-of-its-kind mission, developing robust methods for extracting gravitational-wave signals from the data and understanding their properties will be essential to maximizing the science return of the mission.

Alberto Vecchio, Professor of Astrophysics at the University of Birmingham and Principal Investigator of the UK contribution to the LISA Science Ground Segment, said, "LISA is a unique space observatory to precisely map the evolution of the universe by tracing the pairing up and mergers of black holes from thousands to millions of solar masses.

"LISA will unveil these cosmic dances all the way to the edge of the universe and discover tens of thousands of compact objects we know nothing about today. This is going to be a breathtaking journey across the cosmos with so many surprises. For many years the UK has been at the forefront of modeling gravitational wave sources and developing sophisticated analysis techniques for the mission and we are thrilled to be working with our colleagues from all over the world to make LISA a success."

LISA will be the first gravitational wave observatory in space. It will consist of three spacecraft launched on the same rocket. During their 18-month voyage to their new home 60–70 million kilometers from Earth, the spacecraft will diverge until they reach their final positions forming an equilateral triangle 2.5 million kilometers from each other.

These three spacecraft will relay laser beams back and forth between each other, the signals are combined to search for gravitational wave signatures that come from distortions of spacetime.

LISA will detect gravitational radiation in the yet unexplored window between 0.1 mHz and 1 Hz, waves that cannot be detected by ground-based detectors.

Waves in this frequency range are created in the collision and merger of two massive black holes, a million or more times heavier than our sun, lurking at the centers of distant, still forming galaxies. LISA will be sensitive to these mergers across the universe's history, directly probing the yet unknown origin and growth of massive black holes.

Unique to LISA is the detection of gravitational waves from stellar black holes swirling around massive ones in galactic nuclei, to probe the geometry of spacetime and test gravity in its foundations. LISA will also detect a large number of binary and multiple compact objects in our Milky Way galaxy to tell us about stellar binary evolution, and "see" the galaxy beyond the Galactic Center, including many objects invisible to all other astronomical instruments.

In short, using only gravity for signals, LISA will complement our knowledge about the beginning, evolution and structure of our universe.

LISA's underlying measurement technology was successfully demonstrated in space with ESA's LISA Pathfinder (LPF) mission in which NASA participated. LPF demonstrated that it's possible to place test masses in free-fall to an astonishing level and that the exquisite metrology needed for LISA meets the requirements.

Provided by University of Glasgow