

With NASA out, Europe mulls building a gravitational-wave observatory on its own

A successor to the Laser Interferometer Space Antenna will compete with two other large space missions for European Space Agency sponsorship. Short on cash, NASA's astrophysics program will begin reassessing its future missions.

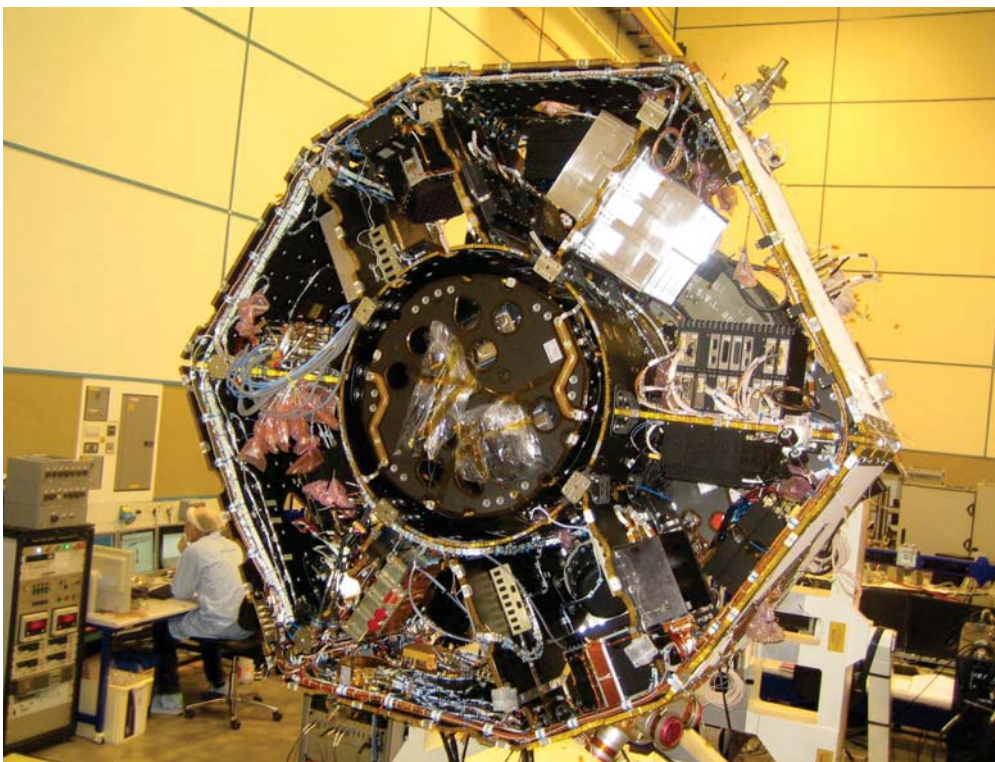
An international collaboration of nearly two decades to launch a gravitational-wave astronomy observatory into solar orbit was upended in April with the dissolution of the partnership between the European Space Agency (ESA) and NASA to build and operate the \$2.4 billion Laser Interferometer Space Antenna, or LISA. But development of a new ESA-led gravitational-wave mission is already under way, and its advocates say that the likelihood of a LISA-like observatory becoming reality sooner rather than later may have risen considerably as a result of the split.

Since 2007, LISA has been among three large-scale project candidates competing for selection under ESA's Cosmic Vision 2015–2025 program. The winner would commence construction in 2015 and be launched in the early 2020s. LISA and the other contenders, the *International X-ray Observatory* (IXO) and the planetary mission Laplace, have each been developed in 50–50 partnership with NASA. Laplace is Europe's half of what has been a two-spacecraft mission with the US for exploring two Jovian moons.

The ESA selection announcement was scheduled for this month. But when the Obama administration's proposed budget for fiscal year 2012 was made public in February, ESA finally stated officially what had been generally known for some time: NASA's astrophysics budget would be insufficient to share the cost of either LISA or IXO on the time scale desired by ESA. The US astrophysics community had already dealt blows to both missions by ranking them below the *Wide-Field Infrared Survey Telescope* in a decadal survey completed last year by the National Research Council. The delayed and over-budget *James Webb Space Telescope* continues to sap NASA's budget for large projects; the agency's FY 2012 request includes \$373.7 million for that mission next year, 35% of the \$1.1 billion total for astrophysics. The telescope is projected to require budgets of approximately that size for at least four more years.

In a separate decadal survey released in March, US planetary scientists ranked the Mars Astrobiology Explorer-Cacher mission higher than the Europa mission, the companion to

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A precursor to the Laser Interferometer Space Antenna gravitational-wave observatory mission, *LISA Pathfinder* is 90% complete and awaits a launch that has been delayed until 2014. The mission is to demonstrate the feasibility of key components that were to have been used in LISA.

Laplace. (See *PHYSICS TODAY*, May 2011, page 23.) As with astrophysics, NASA's planetary program can't support more than one large mission.

Facing those realities, ESA informed NASA in early April that it would proceed to build LISA, IXO, or Laplace alone. On 19 April the European scientific teams for the three projects were told to submit new proposals for spacecraft that could be built and launched early in the next decade using only funds from within Europe. The rescope missions will be considered by the ESA governing board next February. A 2015 construction start is still envisioned.

Rescoping has begun

A ceiling of €850 million (\$1.3 billion) has been set for ESA's contribution to the Cosmic Vision, up from the €700 million it had offered when NASA was a partner. But ESA's member nations are expected to kick in additional

funding, and the total available for the selected mission is expected to be more than €1 billion. Estimated to cost \$5 billion, IXO clearly can't be trimmed to fit the ESA budget, but Karsten Danzmann, the University of Hanover physicist who was European chair of the LISA science team, anticipates that the IXO team will have no trouble coming up with a smaller-scale telescope proposal. But Danzmann expects that the available funding will be no more than €200 million shy of the €1.3 billion ESA has estimated it would cost to build LISA as a European-only project. His team has set about revising the project to fall within the smaller funding envelope. "We have several options," he explains. "We can go to a smaller launcher; we can change the orbit; change the propulsion; change the satellite map. All will cost a little bit of the science, but it's pretty benign."

Some ammunition for LISA's case is provided by its ranking one notch

higher than *IXO* in the US decadal survey. The scientific benefits of Laplace, which was to visit Jupiter's moon Ganymede as a companion to NASA's Europa mission, won't be so clear if the ESA mission voyages alone, says Sterl Phinney, a Caltech astrophysicist who led LISA's US mission definition team and was a member of the project's international science team.

Proponents of LISA argue that although several x-ray observatories are already in place and many missions to the outer planets have been undertaken, no gravitational-wave experiment has been performed in space. "LISA is a very special mission in that it would be the first in its wave band [0.0001–0.1 Hz]," says Phinney. "It was also designed so that it did everything you could conceive of doing, in the sense that it was limited by the cosmic background of all the binary stars in the universe. So there is no point in making it any better than it was. It was sort of the perfect mission in that it would do essentially all of the science that you can do in that wave band for all eternity."

With LISA, Danzmann says, "we can measure the spin vectors of coalescing supermassive black holes, something that no other conceivable observatory could do." The gravitational waves emitted will signal "the early seeds of black

hole formation, far out to redshifts larger than 10, 20, or even further. That's where it all started, out to the dark ages."

LISA Pathfinder

Another factor in LISA's favor is the considerable investment ESA has already made in its precursor, *LISA Pathfinder*. The €300 million spacecraft will demonstrate the feasibility of some key components for the gravitational-wave observatory. As designed, the full LISA would consist of three identical spacecraft arrayed in an equilateral triangle pattern with sides 5 million kilometers long. Each craft would shield within it a freely floating test mass and would house lasers and antennas that would use interferometry to precisely measure the distance to the other spacecraft. Gravitational waves would be detected through the tiny changes that occur in separation of the test masses.

The principal investigator of *LISA Pathfinder*, Stefano Vitale, says the project is expected to demonstrate that the level of spurious acceleration of the test masses, which are gold-platinum cubes 5 centimeters on a side, is minimal enough that it won't drown out the signal from gravitational waves. *LISA Pathfinder* also will demonstrate the lasers and the NASA-developed microthrusters to make the minute adjust-

ments needed to keep the three spacecraft in precise alignment as they co-orbit with Earth around the Sun.

Previously planned for launch this year, *LISA Pathfinder* is now 90% complete. But a problem with the development of a component required to lock the test masses in place during launch has set back the launch to 2014, says Vitale. He and Danzmann say that the money spent on *LISA Pathfinder* will be wasted if ESA does not follow up by choosing the gravitational-wave observatory mission. But Stephen Merkowitz, assistant director for policy and planning in the astrophysics division of NASA's science directorate, argues that *LISA Pathfinder*'s delay already calls into question ESA's timetable for the launch of a LISA-like mission. "If you want to launch a [full] mission in the early 2020s, you really need the *Pathfinder* results fairly soon," he notes. "It's going to be very challenging for the gravitational-wave community to make a case for a mission that is strongly dependent on *Pathfinder*." The US astrophysics community's preference, reflected in the decadal survey, was to shoot for a launch in about 2025.

NASA's program up in the air

Although it was hardly a surprise, ESA's decision to go it alone has left its

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erstwhile partner in the lurch. “We’re facing a situation where our partner is no longer available and those missions no longer can look like what they were described as in the decadal [survey],” notes Merkwowitz. NASA will continue through September to fund the LISA and IXO project teams, most of whose members are located at NASA’s Goddard Space Flight Center and the Jet Propulsion Laboratory. In the meantime, the agency will begin seeking input from the community about how to redirect its astrophysics program. But changes will have to await ESA’s selection process, Merkwowitz says. “If they choose the gravitational-wave mission, that would push us in one direction. If they choose a planetary mission, that would leave two of the astrophysics areas untouched.” It’s likely that the agency will request a study from the National Research Council about a year from now, he says.

Merkowitz sees no clear front-runner in the ESA contest. Europe’s proven experience with building x-ray observatories indicates that “it’s not a big stretch for them to come up with a really good x-ray machine,” he says. And NASA’s planetary science program has offered to contribute some instrumentation for Laplace, should ESA

choose to take that course.

Whatever mission ESA chooses, Merkwowitz says NASA shouldn’t be counted out as a participant. He says the two agencies have agreed that each of the three design teams will include a NASA representative, capable of speaking for the US scientific community and sufficiently versed in fiscal realities to be realistic about potential US contributions. Should ESA ask NASA to contribute as a minor partner, the US agency will want input from the science community first.

What’s been lost

If the LISA-like mission does win the ESA contest, it clearly will proceed more quickly without NASA as a partner. “Europe has money it wants to start spending in 2015, but it was clear that NASA wasn’t going to match that,” notes Phinney. He adds, “There was this problem of synchronizing, and I think it is probably easier to keep to a timetable if it’s one agency that is doing it.” Danzmann agrees: “Had ESA waited for NASA, LISA would not fly before 2025 or 2030.”

Since the NASA–ESA partnership was signed in 2004, ESA has been spending 5 to 10 times as much as NASA on LISA and *LISA Pathfinder*

and carrying out industrial studies. In FY 2011 NASA spent about \$3 million on LISA. Phinney, who personally wrote the first four of the seven versions of LISA’s science documentation, says that although the US has often been more important than Europe in the project’s science and data analysis, “Europe has come to completely dominate the hardware side.” More recently, he adds, “the contributions to the science and data side have become more nearly equal.”

Still, there is disappointment on both sides of the Atlantic on the ending of LISA as it was known. “It hurts to give up some of the science, because we have spent 19 years optimizing this mission concept,” says Danzmann. “The tragedy,” says Phinney, “is that unlike many other missions, LISA has been through many years of industrial studies. There were blueprints, flight hardware, and all kinds of stuff. Now, even if you descope only a little bit, you sort of lose all of that in designing a new mission. It’s a tragic waste.”

Phinney adds, “The mission was born and bred [in the US] and it’s sort of a shame that yet again, the US is dropping its technological and scientific leadership.”

David Kramer

Caribbean Science Foundation sets sail

Initial investment for the funding agency will come largely from the region’s diaspora scientists, from corporate sponsors, and from development banks.

A week-long trip to the Caribbean

in March was more business than pleasure for MIT electrical engineer Cardinal Warde, who spent his spring break courting potential backers for the region’s new science funding agency. The Barbados native is cofounder and interim executive director of the Caribbean Science Foundation (CSF), which launched last fall to promote “the aggressive development of Science, Technology and Innovation” in the tourism-dependent region.

This summer Warde will make stops in London, Toronto, and other enclaves of the Caribbean diaspora to solicit contributions to the \$13 million operating budget that the CSF has set for its first three years. “We will put the bulk of our money into entrepreneurial projects,” he says. “We need to pick the low-hanging fruit. The most expedient way forward is for us to let the developed world continue to do the basic research, which is expensive, and we’ll use [that knowledge] to get products to market quickly.”



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Jamaica native and North Carolina State University student Joseph Washington (left) and University of the West Indies student Jevon Beckles (right) from Trinidad and Tobago pose at the IBM Thomas J. Watson Research Center with their summer internship mentor, Nicholas Fuller. Connecting scientists like Fuller, a native of Trinidad and Tobago, with the Caribbean region’s best and brightest is one goal of the new Caribbean Science Foundation.