We’re So Sorry, Uncle Albert

NASA’s new focus on exploration closer to home may derail missions aimed at torture-testing Einstein’s relativistic ideas

Einstein is in trouble. A century after his “miraculous year,” astronomers and physicists across the globe have plotted an ambitious, multibillion-dollar challenge to Einstein’s theory of relativity. Armadas of spacecraft launched over the next 2 decades will directly test some of the most dramatic assertions of relativity theory: that the entire fabric of space and time ripples with distortions, that there are regions in space where gravity is so strong that light cannot escape, and that the big bang and newly discovered “dark energy” leave a characteristic imprint upon the very distant and very ancient universe. Two great observatories, three smaller probes, and a pair of “vision missions”—which make up NASA’s “Beyond Einstein” project—are the culmination of years of planning by astrophysicists.

The problem is not the tests. Most physicists believe that Einstein’s theories will pass them handily and emerge strengthened by the new data. But when and whether the flotilla will be launched is now in question. When President George W. Bush announced last January that NASA would focus on lunar and Mars exploration by robots and humans, Beyond Einstein, which does not fit into that vision, faltered. The Administration cut budgets for parts of the effort and put others on the back burner.

“I sincerely hope [Beyond Einstein] will survive,” says Michael Garcia, an astrophysicist at the Harvard-Smithsonian Center for Astrophysics in Cambridge, Massachusetts. “I think it’s taken a hit already.” Unfortunately, Einstein’s trouble may be that he’s no longer an important part of NASA’s universe.

Wrinkles and holes in time

NASA’s Beyond Einstein effort tied together two existing projects called the Laser Interferometer Space Antenna (LISA) and Constellation-X, envisioned a new series of probes designed to answer fundamental questions raised by Einstein’s work, and proposed innovative future missions to study black holes and peer back to the big bang. Launched with fanfare in February 2003, the program won congressional backing and the full $59 million NASA requested for 2004. It was an auspicious start for an effort estimated to cost $765 million during the first 5 years.

Beyond Einstein is aimed at addressing questions about Einstein’s theory of relativity and about the nature of black holes and galaxies. LISA and Constellation-X, the two main observatories of the Beyond Einstein project, are both expensive flotillas of spacecraft, yet they attack those questions in very different ways.

LISA comprises three spacecraft that will surf the swells of spacetime, flying in formation—a 5-million-kilometer-wide triangle, linked by laser beams. As gravitational waves rattle by, they will stretch and squish space—time enough to change the relative positions of the three satellites by a fraction of a millimeter (Science, 16 August 2002, p. 1113). LISA will be able to see gravitational waves that earthbound observatories can’t, in part because the vast distance between the satellites will make it much more sensitive.

“The odds are in favor to see a substantial signal,” says Peter Bender, a gravitational physicist at the Joint Institute for Laboratory Astrophysics in Boulder, Colorado. LISA should be able to pick up gravitational waves from various energetic events: the coalescence of massive black holes at the centers of galaxies, the inspirals of black hole binaries in the last moments before they collide, and perhaps even the ripples in space caused by a supernova explosion.

Detecting waves from these events will not only provide a ringing confirmation that Einstein’s gravitational waves are real but will also tell astrophysicists about the nature of black holes and galaxy formation. “During the initial formation of galaxies, we think that they form hierarchically,” says Bender—that small galaxies merge to form larger ones. “Whenever galaxies coalesce, you’re likely to have their black holes coalescing also.” So by listening to the ripples caused by crashing black holes, scientists would get a direct view of galaxy birth.

Constellation-X will also look at black holes, by sensing high-energy light. Matter close to a black hole is extraordinarily hot and emits x-rays; as a hunk of matter falls in, the immense gravitational field of the black hole stretches those x-rays and makes them redder and redder. “You can watch [a black hole’s x-ray emissions] change through time,” says Garcia. “You can watch it move from the blue to the red end of the spectrum.” To spot those changes, scientists plan to yoke together four x-ray telescopes—their size limited by the rockets that will launch them into orbit—to form a larger instrument powerful enough to help physicists map spacetime right near the edge of a black hole.

Plans for Beyond Einstein also include three probes to complement the two large observatories. The Inflation Probe—conceived of as a joint NASA/Department of Energy (DOE) mission—will survey the skies for supernovae. A large census of supernovae, which serve as cosmic yardsticks, will enable astrophysicists to home in on the properties of dark energy, the mysterious antigravity force that is causing the fabric of spacetime to expand faster and faster. “If you talk to anyone at any level at NASA...”
or DOE, they still seem very excited about it,” says Saul Perlmutter, a supernova expert at Lawrence Berkeley National Laboratory in California who is working on one of the proposed designs for the dark energy mission. “I’m hoping you’ll see all the important missions get a chance.”

**The dice game**

When the Beyond Einstein project was launched in 2003, the auspices were good. Prioritization studies by physicists and astrophysicists gave LISA, Constellation-X, and some of the probes a very high rating.

As a result, Congress backed the project and gave NASA the money it asked for to start Beyond Einstein on its way.

Then, a year ago, NASA slammed on the brakes. After Bush called for humans to return to the moon and eventually travel to Mars, White House and NASA managers diverted money from efforts like Beyond Einstein to get that program under way. NASA asked for only $40 million for the entire Beyond Einstein effort in 2005, delaying LISA and Constellation-X each by several years and indefinitely postponing the other missions (*Science*, 6 February 2004, p. 749). After receiving $25 million for LISA in 2004, NASA asked for only $19 million in 2005. Similarly, the proposed budget for Constellation-X dropped by nearly half, from $23.4 million to $12 million. And the agency slashed $1 million from the $10.5 million set aside in 2004 to start work on the other missions.

The decision to retrench stunned scientists. “I really hope the situation is going to change and NASA will take another look at their overall priorities,” says Bender. “There’s been a lot of work by the astrophysical community to determine their decadal prioritization, and the dropping of a substantial piece of that looks like a mistake.”

Congress reluctantly complied with NASA’s less enthusiastic plan in December, approving the Administration’s request. A congressional aide says that many lawmakers were unhappy with NASA’s decision to pull back but that the Beyond Einstein projects can’t match the political clout of more mature projects. “They are not so entrenched yet, so

that makes them vulnerable,” the aide says. He predicts that without strong congressional pressure, Beyond Einstein funding will continue to be squeezed by NASA managers.

Worse may be yet to come. The agency still must allocate hundreds of millions of dollars in congressional earmarks, as well as space shuttle and Hubble Space Telescope costs, within its 2005 budget. And both NASA officials and outside scientists fear that younger efforts like Beyond Einstein will bear the brunt of those cuts, which likely will not be announced until late February, weeks after the 2006 White House budget request goes to Congress.

One way around the financial squeeze might be to find allies with expertise and money. NASA and the European Space Agency (ESA) agreed last August to work together on the two separate missions that make up LISA, to the tune of $1 billion per agency. The first flight is a 2008 dress rehearsal known as LISA Pathfinder to test advanced technologies to be used on the later LISA mission.

But already the tremendous complexity of the technologies has led to cost overruns and schedule delays. Two of the most difficult engineering challenges are to keep the innards of the LISA satellites on the correct path to within a nanometer or so and to ensure that disturbances such as solar photons and the spacecraft’s own electrical systems don’t affect the measurements. The key is a gravitational reference system, which will be NASA’s main contribution to LISA Pathfinder. But cost increases on that system triggered a cancellation review last fall—which it survived—and another will take place in March. Bryant Cramer, Beyond Einstein program manager at Goddard Space Flight Center in Greenbelt, Maryland, says he is confident the system will survive the next scrutiny as well. In the meantime, technical challenges have postponed the launch of LISA Pathfinder from 2007 until the summer of 2008.

Once in space, LISA Pathfinder’s results will immediately be fed into the design of LISA itself, in preparation for a 2013 launch of the three-satellite system. As a result, any delay to the first mission will ripple back, affecting not only LISA but possibly the other Beyond Einstein missions waiting in the queue.

After LISA comes Constellation-X. But plans for a 2013 or 2014 launch have already been abandoned in the wake of the cuts. Paul Geithner, Beyond Einstein program manager at NASA headquarters, says that the mission won’t get off the ground before 2016, and other agency managers predict it will be several years later than that. As with LISA, funding trouble makes a partnership with ESA more attractive to NASA. The two agencies now are in negotiations to combine their efforts.

The three Einstein probes are next in line, although their fate is uncertain. “They haven’t been dropped, merely put on hold until we understand the budget situation,” says Cramer. Coordination between NASA and DOE on the Joint Dark Energy Mission, for example, continues despite the space agency’s decision not to fund the effort. “They’ve got the money, and we don’t,” Cramer adds. Although legislative language in DOE’s funding bill suggests DOE could take over the mission, “we still hope to partner with NASA,” says Robin Staffin, director of DOE’s high-energy physics program. A few advanced concept studies are under way, to the tune of $100,000 each, but “the real money doesn’t kick in for some time,” says Geithner.

Geithner and Cramer are nevertheless confident that the scientific promise of Beyond Einstein will ultimately carry the day. “Sensible people will see that these projects offer a whole new window into the universe,” he says. “And Congress always resists” NASA’s efforts to rob science to pay for space-flight missions, he notes. Cramer believes that LISA in particular has enough scientific cachet to do this mission, though it may be slower” than anticipated, he adds.

And Geithner contends that despite the budget competition, his program is here to stay. “It’s going to happen,” he insists. “Beyond Einstein is not going away.”

—CHARLES SEIFE AND ANDREW LAWLER

**Stalled.** Constellation-X’s fleet of planned black hole–detecting x-ray satellites will remain an artist’s conception until 2016 or beyond.