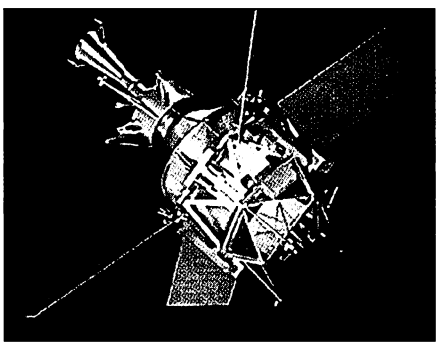
ASTROPHYSICS

Einstein Probe Remains Earthbound

A NASA-funded effort by Stanford University to test Einstein's theory of relativity faces $70 million in cost overruns and an additional 6-month launch delay. This setback is the latest in a long-running series of technical snafus and political tensions that have plagued the experiment. Frustrated NASA managers say they will decide this summer whether to kill the Gravity Probe B effort, but they seem unlikely to carry through with the threat.



Time warp. Launch delay and cost overruns confront relativity test.

Originally slated for a 1999 launch, the probe is designed to measure how Earth's mass warps space-time. Physicists say the results could provide hard evidence to prove Einstein's theory. To make those delicate measurements, the science package of the spacecraft is contained within a supercooled structure that resembles a giant thermos bottle. But problems with gyroscopes contained inside that package, coupled with inadequate cooling in the neck of that bottle, are forcing time- and money-consuming fixes. The situation is "annoying, very embarrassing, and very frustrating," concedes the mission's principal investigator, Stanford physicist Francis Everitt.

How much money and how much time those fixes will take is a matter of heated debate. Much hinges on a series of tests slated to begin in May and conclude later this summer. Everitt insists that there is at least a 50–50 chance that the probe can still be launched as scheduled by September 2001, with a cost overrun of about $40 million. But an independent panel assembled by NASA space science chief Ed Weiler puts the cost overrun at $70 million. The panel is also significantly less confident that Stanford will meet the September launch date. Rex Geveden, the program manager at NASA's Marshall Space Flight Center in Huntsville, Alabama, says, "No one is taking that date seriously." He thinks April 2002 is more likely.

Science obtained a copy of the report of the panel, which was led by retired Lockheed Martin engineer Parker Stafford. It concludes that "the project is in good shape from a technical standpoint," but says Stanford needs an experienced integration and test manager as well as NASA engineers onsite to monitor progress. The Stafford panel also takes NASA to task for repeatedly threatening to cancel the program, which the report says undermined Stanford's confidence and led the university team to be less than forthright about the technical difficulties it encountered.

Irritated NASA officials complain that Stanford managers have not been clear about technical problems, and they assert that the Stanford team has repeatedly gone over their heads by lobbying Congress for support. But Everitt insists Stanford has been up front all along. Nor does he think the extra funding will be a terrific strain, as NASA promised in 1994 to set aside $53 million in case of probe overruns.

That money, however, is not in the bank. Weiler says he must cut other programs to save the probe. In jeopardy are the Europa orbiter, which could be delayed by more than 2 years, or plans for new spacecraft in a series of ongoing midsize science payloads, says the space science chief. The other option, he threatens, is to kill the probe, but Weiler admits he hesitates to do so given the $450 million and 3 decades already invested in it. Weiler intends to wait until critical tests are completed this summer before making a final decision. Even Everitt agrees that if the probe does not come through the tests with flying colors, then "it will be very reasonable for NASA to ask very serious questions."

–ANDREW LAWLER

HELIOSEISMOLOGY

Solar Physicists Get a Glimpse of the Far Side

The far side of the sun seems inaccessible, obscured from our view by 1.4 million kilometers of hot, seething gas. But because the sun rotates every 27 days, that hidden face emerges without fail to shine upon us and, at times, launch dangerous storms our way. Now, researchers may have learned how to detect storms brewing on the far side of the sun, 2 weeks before they swing toward Earth, thanks to a technique that literally hears the rumbling of big sunspots through the sun itself.

The technique, dubbed "helioseismic holography," relies on acoustic vibrations that ring the sun like the solar system's largest bell. On page 1799 of this issue, solar physicists Charles Lindsey and Douglas Braun of the Solar Physics Research Corp. in Tucson, Arizona, explain how they unraveled tiny stutters in those vibrations and traced them clear across the sun to a massive disturbance on the other side. Although their first acoustic hologram of this region is smudgy, the researchers say their images should improve. Says Lindsey: "In a very short time, we will monitor the far side of the sun routinely for large active regions."

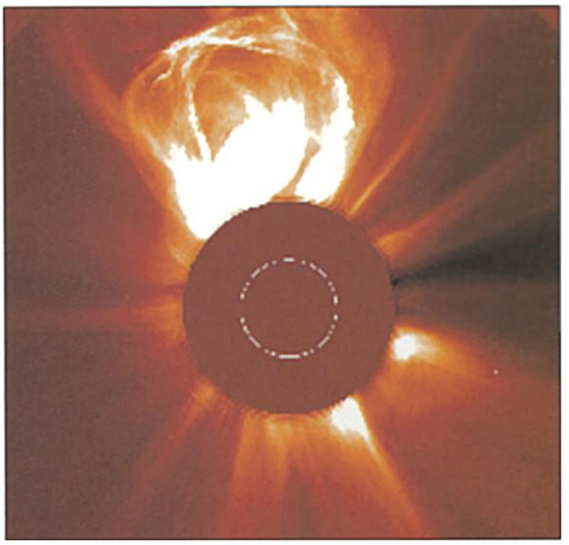
That prospect has lit up the solar physics community. "It's so exciting that we can now manage to look at the far side of a star," says Bernhard Fleck, the European Space Agency's project scientist for the Solar and Heliospheric Observatory (SOHO), which gathered the helioseismic data. "Using the entire sun as an acoustic lens is an elegant and brilliant idea." Those who stare at the sun for its potential impacts on Earth are equally enthusiastic. "This presages a daily analysis of activity on a region of the sun that has been completely out of bounds to us," says Ernest Hildner, director of the Space Environment Center at the National Oceanic and Atmospheric Administration in Boulder, Colorado.

Although it took a decade for Lindsey and Braun to make their concept work, they maintain that it's simple in principle. Gas churns within Texas-sized convection cells near the sun's surface. Those motions propel acoustic waves into the star, where they skip and reflect until the entire sun hums in a complex, low-pitched cacophony. Many vibrations cancel out, but some reinforce one another to create resonant frequencies, like the deep tones within an enormous organ pipe. The Michelson Doppler Interferometer aboard SOHO and ground-based instruments spot those frequencies by using Doppler-shifted sunlight to reveal throbbings of the sun's surface, which rises and falls by tens of kilometers every few minutes.

During their travels, the acoustic waves speed up when they encounter high gas pressures and temperatures deep within the sun or strong magnetic fields near the surface. Sunspots and other storm centers at the surface usually lie within vast regions of strong and tangled magnetic fields, called plages. These magnetic fields press the sun's surface downward by 100 kilometers or more. That shortens the distance that some acoustic waves travel, making them reflect within the sun more quickly than they otherwise would. It's like a dent in the organ pipe, Lindsey says: Waves bouncing off such a region get slightly out of phase with the rest and disrupt the resonant frequency.

Lindsey and Braun saw such a pattern when they analyzed SOHO data from 1998. On 8 April, a major active region appeared on the eastern limb of the sun as it rotated. Tracing backward, the researchers calculated that the region lay on the far side oppo-

CREDIT: LOCKHEED MARTIN



Angry star. A new technique that reveals magnetic disturbances on the far side of the sun may give 2 weeks' advance warning of major solar storms, such as this massive ejection of gas on 27 February.

CREDIT: SOHO/LASCO CONSORTIUM/ESA/NASA

site SOHO's vantage point on 28 and 29 March. Sure enough, the travel times of certain waves sped up by about 6 seconds on those days—a mere hiccup during their 3.5-hour journeys from the near to the far side, but enough to create a splotch in the acoustic signatures. Many such analyses over the face of the sun allowed the team to construct a fuzzy hologram of the hidden plage, which covered 300 square degrees of the sun's surface.

That's a gigantic swath, but the technique can't yet visualize anything much smaller than 100 square degrees. "We're working on improving our resolution, but the larger regions are exactly the ones of most interest to space-weather forecasters," says Braun, who now works at Northwest Research Associates Inc. in Boulder. The method can detect active regions within about 50 angular degrees of the center of the sun's opposite face, Braun notes, although he is now devising ways to extend the analysis to areas near the edge of the far side.

Indeed, researchers at the Space Environment Center often see huge plages rotate into view on the sun's eastern limb "angry and ready to explode," says Hildner. That gives the forecasters no more than a week's warning before the regions may take aim at Earth with a barrage of flares and coronal mass ejections, huge belches of plasma laced with magnetic fields. Solar physicists are still struggling to understand which plages will erupt and which outbursts will affect Earth once they arrive (*Science*, 24 December 1999, p. 2438). Even so, another week of advance warning may help electrical utilities or satellite operators plan for possible disruptions and put key instruments into a safe mode. "If this technique can reveal which active regions are growing in magnetic strength as they cross the far side of the sun, that's enormously promising," Hildner says.

Protecting humans in space may be the greatest benefit, especially with astronauts due to spend thousands of hours on spacewalks during the next decade to assemble the international space station. With far-side monitoring, "we probably will be able to give a general 'all-clear' notification that we see no evidence of big active regions for the next 2 weeks or so," says William Wagner, discipline scientist for solar physics at NASA headquarters in Washington, D.C. However, such an alert system would require continuous listening and rapid analysis of the sun's acoustic symphony. That may fall to the next generation of solar satellite beyond SOHO or to a ground-based helioseismic network now being upgraded: the Global Oscillation Network Group, appropriately known as GONG.

–ROBERT IRION

PLANETARY SCIENCE

Buried Channels May Have Fed Mars Ocean

A team of geophysicists may have found a missing link in the growing body of evidence that Mars once had a major ocean. On page 1788 of this issue of *Science*, researchers analyzing gravity data from the Mars Global Surveyor (MGS) spacecraft report that they have detected a system of now-invisible, buried channels that delivered water from Mars's southern highlands into the northern lowlands billions of years ago. If they're real, these channels "greatly increase the chances of an ocean" on early Mars, says geophysicist Norman Sleep of Stanford University. But MGS geophysicist Roger Phillips of Washington University in St. Louis warns that "whatever it is, it's going to be tough to test."

Signs of an early ocean on Mars have been accumulating for years, but the evidence has been far from conclusive. First, geologists spied hints of a shoreline around the northern lowlands in 20-year-old Viking images, although preliminary analysis of more detailed MGS images has failed to confirm them. Then, after MGS topographic measurements showed the northern lowlands to be the flattest, smoothest known surface of broad extent in the solar system, planetary geologist James Head of Brown

ScienceScope

Bright Idea Indian researchers could soon share in the fruits of their labors. The Indian government last week presented Parliament with a budget proposal that would give institutions full intellectual property rights to ideas developed with public money and allow inventors to share in any profits.

The $2.8 billion R&D budget, which gives a 20% boost to civilian research and an 11% increase to military science, would reverse existing rules that allow funding agencies to patent discoveries but cut universities and scientists out of any royalties. Asis Datta, vice chancellor of New Delhi's Jawaharlal Nehru University, says the new policy could be just what "universities need to unleash their creative potential." Parliament is expected to approve the change later this year.

Warming to Hot Zone After months of delay, Canada is preparing to open its borders to some of the world's most dangerous pathogens. Last week, a community panel endorsed a plan for the Canadian Science Center for Human and Animal Health in Winnipeg to open a biosafety level 4 lab.

Shortly after the center's dedication last summer (*Science*, 18 June 1999, p. 1902), officials admitted to accidentally releasing waste water into the city sewage system without properly heating it to kill germs. A review concluded that the release posed no threat, but riled neighbors caused the government to delay issuing a permit to work with high-risk level 4 pathogens, such as the Ebola virus. To restore confidence, the lab invited local residents to join a new community liaison committee, which gave the lab's safety procedures a green light on 2 March. A thumbs-up from the government is expected shortly.

Choices, Choices After a 13-month search, the Department of Energy's Pacific Northwest National Laboratory in Richland, Washington, has named Lura Powell, a former administrator at the National Institute of Standards and Technology, as its new director. The choice pleased DOE Secretary Bill Richardson, who last fall reportedly derailed the lab's first choice, saying lab contractor Battelle had not tried hard enough to find a woman or minority to fill the post. Similar concerns have stalled the search for a new leader of DOE's Argonne National Laboratory in Illinois.

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