strengthening greenhouse might have on the AMO, adds Sutton. Most helpful would be an understanding of the AMO's ultimate pacemaker. In the Hadley Centre model, report modelers Michael Vellinga and Peili Wu of the Hadley Centre in Exeter in the December *Journal of Climate*, the pulsations of the conveyor are timed by the slow wheeling of water around the North Atlantic. It takes about 50 years for fresher-than-normal water created in the tropics by the strengthened conveyor to reach the far north. There, the fresher waters, being less dense, are less inclined to sink and slide back south. The sinking—and therefore the conveyor—slows down, cooling the North Atlantic and reversing the cycle.

That may be how the Hadley AMO works, says oceanographer Jochem Marotzke of the Max Planck Institute for Meteorology in Hamburg, Germany, but it doesn't settle the mechanism question. How a model generates multidecadal Atlantic variability "seems to be dependent on the model you choose," he says. Before even tentative forecasts of future AMO behavior are taken seriously, other leading models will have to weigh in, too.

–RICHARD A. KERR

Astronomy

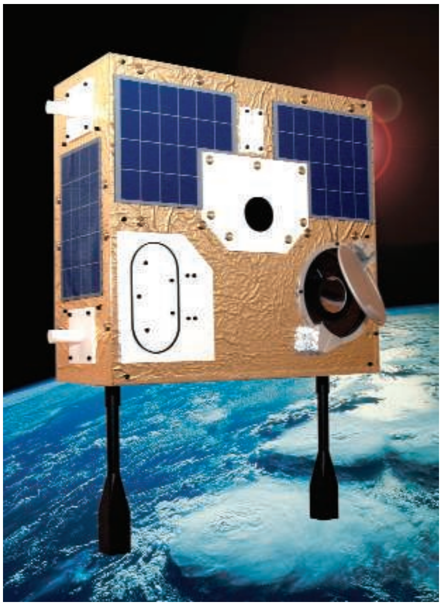
Suitcase-Sized Space Telescope Fills a Big Stellar Niche

Small but single-minded, Canada's MOST microsatellite is revealing the inner clockwork of stars and characterizing exoplanetary systems

MONTREAL, CANADA—To astronomers, bigger telescopes usually mean better telescopes. But a Canadian space-based instrument is bucking that trend. Just 2 years into monitoring subtle periodic dips in starlight, the suitcase-sized MOST (Microvariability and Oscillations of Stars) telescope is probing the hidden internal structures of sunlike stars and pinning their ages down to a greater precision than ever before. At a meeting here,* astronomers announced that MOST has also begun to provide information about the planets that orbit some of those stars, even hinting at their weather patterns. "Not bad for a space telescope with a mirror the size of a pie plate and a price tag of $10 million Canadian, eh?" says astronomer Jaymie Matthews of the University of British Columbia.

MOST blasted into space aboard a converted Russian intercontinental ballistic missile on 30 June 2003. Nicknamed "the Humble Space Telescope," Canada's first space observatory is also the world's smallest, weighing in at only 60 kg and sporting a modest 15-cm mirror. Designed and built for less than 1/20 of the projected cost of any upcoming competing mission, the single-purpose satellite does without most of the instruments found on its larger space-based cousins but still conducts science no other orbiting observatory is equipped to do.

Above the blurring effect of our atmosphere, MOST's ultraprecise photometer can detect fluctuations in stellar brightness as small as one part in a million—10 times better than ground-based telescopes can achieve. Thanks to a specially designed gyroscope, the Canadian Space Agency–run microsatellite can stare at a star around the clock for up to 2 months. The Hubble Space Telescope, by contrast, can look at a given object for only about 6 days. "MOST is pushing frontiers in stellar astronomy in terms of time sampling and light-measuring precision," Matthews says. "While this may seem more abstract than what Hubble can do, it is just as revolutionary in terms of what this tiny telescope allows us to see in stars and their planets."



Packed with potential. Boxy MOST focuses on doing one thing very well.

CREDIT: E. KOELEMEYER/MACMILLIAN SPACE CENTRE

Using methods of asteroseismology—the study of starquakes—MOST monitors optical pulsations caused by vibrations of sound waves coursing through a stars' deep interior. Just as geologists can map Earth's interior from earthquake signals, astronomers can probe a star's hidden structure by tracking minute oscillations in its luminosity. As the star contracts, its internal pressure increases, heating its gases and temporarily increasing its brightness. The MOST team hopes the technique will lead to better theories about how stars evolve with age.

"Most of the research is being done on sunlike stars, because we know how to interpret the data using our sun as a model," says starquake hunter Jørgen Christensen-Dalsgaard of the University of Aarhus in Denmark. According to astrophysical models, stars between 80% and 170% as massive as the sun pass through the same basic life cycles as the sun does and should show similar upper atmosphere turbulence and micromagnitude oscillations. But whereas short, subtle changes in brightness are relatively easy to detect on the sun, they are much trickier to spot in more-distant sunlike stars.

Not until 2000 did ground-based telescopes become sensitive enough to confirm them in a few dozen solar-type stars. Those observations used spectroscopes to detect shifts in the color of light, from which astronomers could calculate the radial velocity of the stellar surface as it moves up and down. Now MOST—which makes it possible to draw similar inferences from much smaller changes in brightness—is opening a new chapter in the field, says astronomer Travis Metcalfe of the High Altitude Observatory in Boulder, Colorado: "This modest instrument is bound to have a great impact on our understanding of stellar evolution."

In July 2004—a year into its observations—MOST's science team, led by Matthews, generated their own waves in the asteroseismology community when they published their observations on the well-studied star Procyon. To the shock of everyone, the satellite found that Procyon showed none of the oscillations that ground-based measurements had seen and theoretical models had predicted for nearly 20 years. "We had 32 continuous days of data representing over a quarter of a million individual measurements and saw nothing," says Matthews.

Asteroseismologists around the world are still puzzling over those observations. Christensen-Dalsgaard, a member of one of

* CASCA 2005, Montreal, Quebec, 15–17 May.

Published by AAAS

the first teams to detect Procyon's oscillations from the ground and biggest critic of MOST's Procyon results, suspects that either light scattered back from Earth into the telescope washed out the data, or "noisier"-than-expected convection in the star's atmosphere made the oscillations unreadable. The possibility of using MOST to study stars' atmospheric churning "is, of course, itself interesting," he adds. The MOST team revisited Procyon this year and plans to publish an analysis of the new measurements within a few months.

Things went more smoothly this year, when MOST fixed its gaze on Eta Bootis. This time the data matched both stellar models and earlier ground-based observations. By comparing the data against a library of over 300,000 theoretical stellar models, Matthews and his team have pegged the star's age at 2.4 billion years, plus or minus 30 million years—about 10 times the precision of previous estimates. Studying a variety of sunlike stars with differences in mass, age, and composition will lead to better models, Christensen-Dalsgaard says.

As a bonus, MOST's ability to measure exquisitely small variations in starlight enables it to double as an exoplanet explorer. At the meeting, the MOST team announced that the telescope had staked out an alien world around a far-off star and turned up subtle hints of an atmosphere and possible cloud cover. NASA's Spitzer Space Telescope had detected the infrared glow from exoplanet HD209458b in March. MOST tracked the subtle dip in optical brightness as the planet slipped behind its parent star during its orbit.

By following the frequencies and amplitudes of the changes in stellar brightness, the team concluded that the planet is a gas giant 1.2 times as massive as Jupiter, parked less than 1/20 as far from its star as Earth is from the sun. Astronomers think HD209458b's low reflectance (less than 40%, compared with 50% for Jupiter) sets limits on the planet's atmosphere, in which the Hubble Space Telescope saw signs of carbon and oxygen in 2004. MOST will conduct a 45-day survey of the system later this summer with the hope of getting a clearer picture of the exoplanet's atmosphere and even its weather: temperature, pressure, and cloud cover.

MOST's asteroseismological monopoly is destined to be short-lived. Similar satellites on the horizon include the European COROT (Convection, Rotation, and planetary Transits) mission, slated for launch in June 2006, and NASA's own planet seeker, Kepler, due in 2007. Unlike MOST, both satellites will be technologically capable of detecting Earth-size worlds. COROT's more sensitive detector will also be able to look at many stars simultaneously, rather than one at a time, as MOST does. But COROT and Kepler will focus on fainter stars than MOST observes, and their vision will be limited to smaller sections of the sky, Metcalfe says. As a result, he argues, during the tail end of its 5-year life span, MOST will complement the other missions and will not become obsolete when they come on line.

Christensen-Dalsgaard agrees. "MOST is giving us the experience that we need to learn how stars behave photometrically and helps us learn how to choose targets for these later missions," he says. "So in the next couple of years, we need to make the most out of MOST."

—ANDREW FAZEKAS

Andrew Fazekas is a freelance writer in Montreal, Quebec.

Central Asia

Combating Radioactive Risks And Isolation in Tajikistan

The science academy of this war-weary country is reaching out for help in tracking down lost radioactive sources—and restoring scientific vitality

FAIZABAD, TAJIKISTAN—In the early 1990s, as civil war raged in this mountainous land, a terrorist's prize was here for the taking. Powerful radioactive sources lay buried in an open-air, gravel-covered pit on a compound ringed by a dilapidated concrete wall and chain-link fence. During the 5-year war, villagers and fighters pillaged nearby apple orchards and industrial sites. But the makings of dirty bombs—including radioisotopes such as cesium, cobalt, and americium in old Soviet gauges and other devices—remained untouched. "We were lucky," says Gennady Krivopuskov, manager of the 6-hectare waste storage facility 50 kilometers northeast of the capital, Dushanbe. "Maybe the radiation hazard signs kept looters away."

How long the rad cops' luck will last is an open question. One or two derelict radioactive generators, which produce electricity from the heat harnessed from the decay of strontium-90, were never moved to this storage facility and remain unaccounted for, experts say. Each radioisotope thermoelectric generator (RTG) packs a whopping 40,000 curies—equivalent to the radioactivity from strontium-90 released during the 1986 Chornobyl explosion and fire. "How serious is it that they aren't secured? Well, that depends on who has them," says a Western diplomat. Last month, a U.S. Department of Energy (DOE) team was in Dushanbe to train specialists at the Nuclear and Radiation Safety Agency of the Academy of Sciences of the Republic of Tajikistan (AST) on how to detect abandoned sources. Search efforts are about to get under way.

Concern about RTGs as a serious proliferation threat first got attention 3 years ago,

Isolation. Barriers have been upgraded at the Faizabad radwaste site, with help from the U.S. Department of Energy.

CREDIT: R. STONE

Published by AAAS