China is latest country to pursue astronomy in Antarctica

At some wavelengths, the advantages of doing astronomy from Antarctica outweigh the challenges.

China has focused on two areas in astronomy for which working in Antarctica would give it a leg up over other countries, says John Storey, an astronomer at the University of New South Wales in Sydney, Australia, who is involved in several Antarctic projects, including China’s. “I think everyone is watching and hoping they go ahead” with telescopes that would explore such things as how stars form, the origins of the universe, dark matter and dark energy, and whether life exists on other planets.

China’s two focus areas are optical/IR astronomy and terahertz, or submillimeter, astronomy; IR and submillimeter wavelengths in particular are generally recognized as promising research directions in Antarctica, and projects are under way by other countries as well. The Chinese plan is to erect several telescopes at Dome A, which at 4093 m is the highest site on the Antarctic plateau and boasts calm, cold, dry, clear skies.

Lifan Wang, an astronomer who splits his time between Texas A&M University and Purple Mountain Observatory in Nanjing, China, says that putting big telescopes on Antarctica “was not a popular idea” in China when he and colleagues first proposed it about five years ago. But the idea has gained momentum thanks to the International Polar Year 2007–08 and because scientists have trekked to the site and determined it to be exceptional for astronomy. “We have proved that we could do something there,” says Wang.

Now, he says, the 2.5-m optical/IR Kunlun Dark Universe Survey Telescope (KDUST) and the 5-m Dome A Terahertz Explorer (DATE) are among the highest priorities of the Chinese astronomical community and have gotten good reviews from the Chinese Academy of Sciences. The combined price tag for construction is estimated to be at least CNY1 billion ($150 million). A decision on funding by the Chinese government was imminent as PHYSICS TODAY went to press. Even if the two telescopes don’t get fully funded this go-around, says Wang, “they are unlikely to die.”

Starting small, aiming large

First up for China, though, is a trio of 50-cm optical telescopes, the Antarctic Schmidt Telescopes (AST3). A platform to supply power and connectivity is being installed at Dome A, and the telescopes will be transported and set up starting in the next Antarctic summer; Kunlun station, the base of operations at Dome A, is not yet habitable year-round. The three independent, remotely controlled telescopes will be used to study variable objects, such as supernova explosions and the afterglow of gamma-ray bursts, and to search for extrasolar planets. “It’s a small but serious astronomical project,” says Wang. “It can do exciting science that cannot be done anywhere else.”
Unlike KDUST and DATE, which will be overseen by the Chinese Academy of Sciences, “AST3 is managed at a low level,” Wang says. “We raised a significant fraction of the money from universities and observatories” for the CNY60 million project.

Moving on to the larger DATE and KDUST will mean not only more money, but also more hoops to jump through and more political involvement in the projects. If included in China’s 2011–15 budget cycle, the telescopes could be completed in 2015 and installed a year later at Dome A. For both the AST3 and the future projects, most or all of the money will come from China. A handful of scientists from Australia, Chile, and the US “contribute mostly through conversations,” says Wang, and about 15 scientists from seven institutions in China are working on the projects.

Antarctica is the one place on Earth where the atmosphere is consistently transparent at terahertz frequencies. The only current efforts in the terahertz range are the European Space Agency’s Herschel Space Telescope and—once up to speed—SOFIA, the airplane-turned-observatory by NASA and the German Aerospace Center. DATE is a precursor to larger terahertz telescopes and interferometers that would be impractical to deploy in space. At the same time, says the project’s leader, Purple Mountain Observatory director Ji Yang, “it can do forefront science, because it opens a new window.” A main research focus for DATE will be star formation.

As envisioned, KDUST would have both optical and IR capabilities. A 15-m-high tower would raise it above the site’s relatively thin atmospheric turbulent boundary layer. With such a setup, says Wang, in about 100 hours, “this telescope can get a very deep image, like the Hubble ultradeep field. We plan to probe the first generation of stars.” By going above the boundary layer, he says, the resolution will be 0.2 or 0.3 arcseconds, or two to three times as good as currently possible. In sensitivity, says Storey, “a 2.5-meter telescope at Dome A can be competitive with 8-meter telescopes in other locations. It’s a way of leapfrogging existing facilities and getting into a whole new parameter space in astronomy—wide-field, high-spatial-resolution, time-domain astronomy.”

Complications and competition

There is a hitch: The technology needed for detecting in the IR is available only in the US and is subject to export controls under the International Traffic in Arms Regulations (ITAR; for more on export controls, see PHYSICS TODAY, October 2010, page 23). “The question does arise as to how China will get access. This goes beyond the pleasures of astronomers,” says Storey. The cause for optimism, he adds, “is that Antarctica is unique. It’s essentially a science park.”

The ITAR issue is just one of many challenges under extreme conditions. The program needs to overcome the tremendous logistical and technical issues such as limited access to the site, remote automated operation, and technical challenges under extreme conditions.

Still, because of the export-control rules, the proposal for KDUST does not include an IR camera, although the telescope is designed to accommodate one. “We hope that another institution, somewhere else in the world, will be interested in contributing an IR camera,” says Wang. He maintains that the project is “absolutely worthwhile” even if it remains limited to the optical part of the spectrum.

Meanwhile, a European–Australian team is also planning a 2.5-m IR telescope, for the French–Italian Concordia station at Dome C, about 200 km from Dome A. The Polar Large Telescope is “quite comparable” to the Chinese project, says the PLT’s leader, Nicolas Epchtein of the CNRS and the University of Nice in France. He stresses, however, that the PLT team ruled out optical wavelengths and would be dedicated to repeated large-scale, near-IR sky surveys. Mainly because of auroras, “the sky is not that dark in Antarctica and is not that good for deep imaging in the optical range,” he says.

The European-led team may have an easier time obtaining the mercury-cadmium-telluride detectors that these telescopes need to observe in the IR. Pointing to the Visible and Infrared Survey Telescope for Astronomy in Chile, Epchtein says “there was no problem buying such detectors for VISTA; the UK could obtain 16 detectors of this type.”

Cold is increasingly hot

In building on Dome A, astronomers are getting a piggyback ride; it and the other observing sites in Antarctica were created for other purposes. The US’s Amundsen–Scott station at the South Pole was established as part of the International Geophysical Year 1957.

Home to a 10-m submillimeter telescope, the subsurface neutrino detector ICE CUBE, and other experiments, it is by far the most developed site. Dome A, Dome C, and Japan’s Dome F station, mounds on the polar plateau within 1300 km of the South Pole and 2000 km of each other, were chosen for ice-core drilling to study climate change. “The places the ice cores have picked out turn out to also be super for astronomy,” says Storey. “For drilling you want to be on a dome to get the thickest ice. For astronomy, you want to be on top of a dome for the altitude and the low wind speed”—low due to the downward flowing, katabatic, winds found in Antarctica.

“We characterize sites to see what aspects [of astronomy] each site would give an advantage to,” says Storey, a coauthor on a 2009 paper that compares the existing Antarctic sites for boundary-layer thickness, cloud cover,
Shortage of plutonium-238 jeopardizes NASA’s planetary science missions

Scientific societies and advisers urge Congress to approve funding to restart production of the radioisotope, which provides the only alternative to solar power for spacecraft.

Cornell University astronomer James Bell thought he had a great proposal for a planetary mission for NASA’s New Frontiers program. His probe would explore the cloud of asteroids that follows Jupiter in its orbit around the Sun. But while the science was compelling, he says, powering the spacecraft was problematic. In NASA’s 2009 solicitation of proposals, the use of radioisotope power systems was specifically excluded. Bell and his team had no choice but to equip his would-be probe with massive solar arrays sufficient to generate power where sunlight is 1/25th its brightness on Earth. That drawback, he says, doomed the proposal.

Bell’s experience illustrates a quandary facing upcoming missions to the outer solar system, and to places like the lunar poles and some craters, where sunlight is faint or never shines: The plutonium-238 that has fueled past missions in those environments is running out. There is only enough left to fuel two of the four NASA planetary missions due for launch before 2020, says Jim Adams, deputy director of NASA’s planetary science division. Absent new domestic production of 238Pu or purchases from Russia, NASA will be unable to explore beyond Jupiter or to probe hostile environments, he says.

Since 1961, 238Pu-fueled radioisotope thermoelectric generators (RTGs) have powered 26 NASA spacecraft used for navigation, meteorology, communications, and explorations of the Moon, the Sun, Mars, Jupiter, Saturn, and the outer solar system. The longevity of the two Voyager probes launched in 1977 is testament to the RTG’s reliability and long life. The devices are simple; without moving parts, they convert the heat generated by the decay of 238Pu directly into electricity. For missions in permanent shade or where sunlight is too dim, RTGs are the only alternative power source.

Who should pay?

But Congress has refused to provide the funding to restart production. Lawmakers last year rejected an Obama administration request for $30 million in fiscal year 2010 for the Department of Energy (DOE) to initiate 238Pu production. Although the appropriators did not dispute the need for new material, they argued that NASA, the customer, should pay the cost. The White House came back with an FY 2011 request of $15 million for each agency. The appropriations process was still pending as PHYSICS TODAY went to press, although Senate appropriators have again rejected funding for DOE’s portion.

Russia, which had sold the isotope for NASA use since 1992, halted sales in 2009, pending the negotiation of a new agreement between the two governments. Although DOE says it expects to procure “a limited amount” of Russian 238Pu, it warns that may not happen for three or four years. Adams says past deliveries from Russia have often been unexpectedly delayed.

In November NASA’s Astronomy and Astrophysics Advisory Committee...