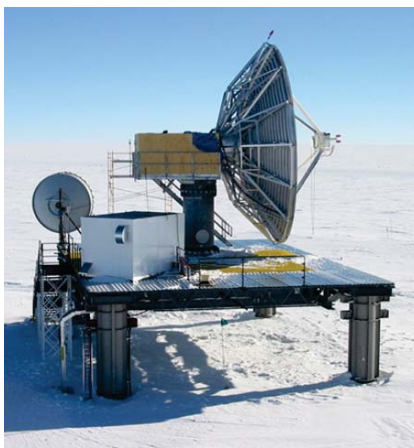


Keeping equipment cool can be a challenge at Antarctic ground station

Michael Ashley's Quick Study, "The care and feeding of an Antarctic telescope" (PHYSICS TODAY, May 2013, page 60), was an enjoyable read. His comment on equipment overheating at ambient temperatures below -60°C and the trickiness of thermal design brought back memories of a similar problem I experienced as the South Pole satellite communications engineer. The South Pole Marisat-GOES Terminal satellite communications ground station (see the photo at right) supported intercontinental communications to the Amundsen-Scott South Pole Station through two old but still viable highly inclined geosynchronous satellites, *Marisat-F2* and *GOES-3*. Not surprisingly, ground station operations and support for this large, complex system in the extreme temperature environment occupied much time on and off ice during my seven years with the program.

For several years after the terminal commenced operation in 2001, unexplained oscillations in the uplink solid-state power amplifier (SSPA) output were observed. They affected link performance and produced corresponding oscillations in the strength of signals received by satellites, particularly for *GOES-3*, which required an uplink power level more than five times that needed for *Marisat-F2*.

The SSPA electronics and power-supply equipment had forced-air cooling. While performing annual equipment maintenance in the terminal's shelter and monitoring the SSPA output one summer day, we serendipitously



The South Pole Marisat-GOES Terminal, in 2002, with a 9-meter full-motion antenna pointed at *Marisat-F2* and a fixed 3-meter antenna pointed at *GOES-3*. Inlet and exhaust vents are opened and closed by temperature-controlled fans housed in the antenna shelter.

noticed the output changing at the same frequency as shelter temperature fluctuations in response to intervals of cooling-fan operation. Clearly, ambient air temperature and its ability to cool were factors in the SSPA output. The South Pole experiences a wide range of atmospheric pressure values, equivalent to altitudes between approximately 3050 m and 3600 m but typically staying around 3200 m in the summer. Mid-summer temperatures usually range between -40°C and -25°C . A 1998 memo¹ by Jingquan Cheng at the National Radio Astronomy Observatory stated that cooling efficiency can decrease by about 15% at 3000 m. Apparently, that efficiency reduction affected the ability to cool electronics by the forced-air cooling system. Anecdotaly, flat-panel plasma displays installed in the new station suffered premature failure, no doubt due to a similar problem with insufficient cooling at altitude.

The solution was relatively simple. We moved the SSPAs to the lowest rack location, disconnected the outside air inlet fan at the bottom of the shelter, and permanently opened the inlet fan vent slightly. The move placed the SSPAs in a cooler location—thermal stratification is quite noticeable—and reliance on

only the exhaust fan at the top of the shelter evened out temperature and corresponding SSPA output variations. Hopefully, our experience can be used by others contemplating electronic equipment operation at high altitude.

Reference

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Kenneth Wilson footnote: Stories of a great competitor

Theoretical physicist Kenneth Wilson, who received the 1982 Nobel Prize in Physics, died earlier this year. (See his obituary in PHYSICS TODAY, November 2013, page 65.) I'd like to share with readers my first encounters with Ken, when we were both undergraduates.

On a particular Saturday in late fall of 1956, when I was a junior at Cornell University, two events were taking place in Ithaca, New York. One was the Heptagonal Indoor Track and Field meet, in which all Ivy League schools participate. The other was the annual William Lowell Putnam Mathematical Competition, a very challenging national undergraduate contest. Six problems were to be solved in three hours in the morning, and another six in three hours in the afternoon. By "challenging" I mean that the median score is often only about 1 out of 12.

As a dual major in math and physics, I had decided to try my hand at the Putnam. Those Cornellians who had signed up arrived at the exam room to find an additional competitor, Ken Wilson, a senior at Harvard University. Not only was Ken taking the Putnam exam in Ithaca by special permission, but he was also running the mile that evening in the Heptagonal Games. The star miler in the Ivy League at the time was

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a Harvard freshman named William “French” Anderson, who would go on to become a prominent physician. During the lunch break, Ken explained to me that his job was to be a pacer: He would run very fast, too fast for a miler, to lead Anderson but then drop back.

When the afternoon Putnam session had ended, I was a bit discouraged. I had picked up an undetermined number of partial credits, but that was all. I asked Ken how he had done. He said he thought he had gotten maybe 11 correct and partial credits on the 12th. It was a humbling experience for me. As it turned out, Ken finished in the top five in the country. (The Putnam folk do not differentiate among the top five.) In the evening, Ken did his running duty as the pacer, and Anderson won the mile.

Late the next spring, the outdoor Heptagonal Games were also held in Ithaca. I sought out Ken. He was excited because his coach had told him that since this would be the last race of his career, he could run the mile at his own speed and not pace Anderson. So he did, and he won, beating Anderson and the rest of the field.

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Teaching skills and scientists’ future impact

As a scientist myself, I appreciated the commentary “The case for caution in predicting scientists’ future impact,” by Orion Penner, Alexander Petersen, Raj Pan, and Santo Fortunato (PHYSICS TODAY, April 2013, page 8). In addition to their cautions about impact factor, I think the performance of academic scientists as educators also should be taken into account.

The impact of a good science educator on the future of science may be difficult to measure directly, but it is certainly of great importance. Educators will shape the future of potential young scientists, from undergraduate and graduate training all the way to post-doctoral research. The better the educator, of course, the more positive the effect on students. Some brilliant research scientists are very poor educators who can barely transfer their knowledge and skills to students, let alone attract good students in the first place.

Maybe it’s time to put more emphasis

on teaching skills and potential in the evaluation of scientists.

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On modeling electrostatic effects in living cells

Regarding the comment by Bob Eisenberg and the response by authors Eli Barkai, Yuval Garini, and Ralf Metzler (PHYSICS TODAY, July 2013, page 10) in discussing electrostatic effects in living cells, I offer the following:

Eisenberg’s rejection of the use of classical, static analysis raises the question of what should be included in a model of a cell in an electrostatic field. Clearly, the field would create a potential across any cell to which it was applied. And such a potential would alter the shape of the cell, in addition to driving a (possibly minuscule) current through the cell and the surrounding fluid or cellular medium. As the cell moved, the shape and possibly the current would change.

Those effects imply much more than plain diffusion, especially if the medium containing the cell differed considerably from the cell’s own contents.

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Acoustical surface states in the radiation continuum

A Search and Discovery report in the September 2013 issue of PHYSICS TODAY (page 14) describes interesting work by Chia Wei Hsu and colleagues on guided optical modes within the radiation continuum.¹ Readers may be interested to know that surface states in the radiation continuum are well known in crystal acoustics. While surface acoustic waves (SAWs) are normally slower than bulk acoustic waves (see PHYSICS TODAY, March 2002, page 42), crystal surfaces support so-called pseudo-SAWs, whose velocity exceeds the slow transverse bulk velocity.

Pseudo-SAWs are leaky because of their coupling to the radiation continuum of bulk modes, but in isolated

propagation directions the coupling to bulk modes disappears and pure surface modes termed supersonic surface waves appear.² Just as in optics, sometimes symmetry incompatibility is involved. For example, in a supersonic SAW found in the [110] direction on the basal plane of cubic crystals such as silicon and germanium, particles move in ellipses contained in the vertical (sagittal) plane, whereas the slow transverse wave is polarized in the horizontal direction orthogonal to that plane. As soon as the wavevector deviates from [110], symmetry incompatibility is lifted and the mode becomes leaky.

However, the same pseudo-SAW branch contains another isolated, pure-mode point in a totally inconspicuous direction.³ Such “secluded” surface-wave solutions within the radiation continuum that are unrelated to symmetry incompatibility are stable with respect to system perturbations such as a change in the orientation of the surface.⁴ Although the existence of supersonic SAWs on a bare substrate requires elastic anisotropy, we found a supersonic mode guided by a layer with a periodic mass loading on an isotropic substrate.⁵ The structure we considered was somewhat analogous to the photonic-crystal slab used by Hsu and colleagues, but with an important difference: In the acoustic case, there are two bulk modes, longitudinal and transverse; our guided mode was faster than the transverse but slower than the longitudinal. Whether a guided mode can be faster than any bulk wave is unclear, since it will require that the radiation into both bulk modes be canceled simultaneously.

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