1997 Pawsey Lecture

Antarctic astronomy—looking at the beginning of the universe from the end of the earth.

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The 1997 Pawsey Lecture was presented on the first of August at the University of Tasmania's Stanley Burbury Theatre in Hobart. Several distinguished guests were preesent, including Sir Guy Green, Governor of Tasmania, and members of the Pawsey family. The following is a brief summary of the lecture.

1. Why do astronomy from Antarctica?

Much of astronomy concerns itself with understanding the origins of things:

- How did the sun and the solar system (including the earth) form?
- Where do galaxies come from?
- How did the universe evolve from the structureless big bang to the present intricate web of galaxies, galaxy super-clusters, voids, etc?

Infrared and submillimetre astronomy represent two of the most effective tools for pursuing these studies. These longer wavelengths (compared to visible light) not only convey the bulk of the energy output from cooler "proto" objects, but also penetrate the dusty universe much better. In addition, at larger redshifts (z) the familiar visible and near-UV spectra are redshifted into the infrared. At a z of 2.5, for example, the important Hα line—so well studied by optical astronomers—appears at a wavelength of 2.3 microns. The cosmic microwave background radiation (CMBR) has a black-body spectrum that peaks at around one millimetre. A wealth of information can be gained from the subtle anisotropies in the spatial distribution of the CMBR, and from the departure from a pure Planckian spectrum in particular directions. Finally, the main "cooling" spectral lines that dominate the energy balance of collapsing molecular clouds are also to be found in the sub-millimetre.

The history of infrared and submillimetre astronomy has been one in which major advances in understanding have followed rapidly on the heels of technological progress. In order to dramatically increase our knowledge, let us therefore ask for an additional factor of ten in sensitivity over what can presently be achieved in the infrared. Where is this "factor of ten" likely to come from? It might be achieved with:

- Better (larger) telescopes
- Better instruments
- Better sites

In the near- and mid-infrared, the largest telescopes in existence or under construction are 8 to 10 metres in diameter (eg, Keck, Gemini, and Europe's Very Large Telescope). The price tag for a single 10 metre telescope is around $100 million. With the cost of a telescope rising almost as the cube of its diameter, it is clear that the next "factor of ten" will not be coming from a simple increase in telescope size in the near future!

The quantum efficiency of near-infrared detectors now exceeds 80%, and arrays of 1024 x 1024 pixels are available. Even in the mid-IR, 256 x 256 arrays are available with quantum efficiencies exceeding 40%. Instrument losses can also be extremely small, especially if reflective optics are used. Small gains in sensitivity are foreseeable, but existing instruments are already close to achieving theoretical performance limits.

This leaves a better observing site as the only hope for a large improvement in our capabilities. Measurements we have carried out at the South Pole have shown that the near-IR sky background can be up to a factor of 100 lower than that at temperate sites. Here at last is our next "factor of ten". (With a background-limited detector, sensitivity goes as the square root of the background flux.) In addition, the incredible dryness of the atmosphere offers dramatically improved transmission at many wavebands, even opening up some regions of the spectrum that are otherwise totally inaccessible from the ground. This is particularly so in the sub-millimetre, a spectral region still barely exploited—largely because of the extreme difficulty of making observations from temperate sites.

2. Where are the best sites?

At the present time, the only comprehensive data we have on astronomical conditions in Antarctica are from the US Amundsen Scott Station at the South Pole. However, the South Pole is not a particularly special place as far as the topography of Antarctica is concerned. Higher, drier, colder sites lie further up the plateau. Locations of particular interest include Dome C, Vostok (a Russian base) and Dome A. None of these locations is currently occupied during the winter (in the case of Dome A, no-one has even been there!)

In order to fully assess the potential of the Antarctic plateau for astronomy, the AASTO (Automated Astrophysical Site-Testing Observatory) has been developed (see article in the previous issue of *The Australian and New Zealand Physicist*). The AASTO can acquire detailed data over a wide wavelength range from any site, even those that are uninhabited. This "robot" observatory can be placed anywhere on the plateau by ski-equipped Hercules aircraft, and operates autonomously for 12 months at a time. The AASTO is currently undergoing shake-down tests at the South Pole, prior to its first remote deployment.

An important feature of the AASTO is its very low environmental impact. The antarctic plateau is a pristine wilderness, and we should only carry out research there if we can do so without damage to the environment. Astronomical research is a very good example of the kind of research that it is largely passive—the measurements themselves create no environmental disturbance, only the infrastructure required to support the measurements. An important element of minimising the impact is therefore the use of uninhabited, robotic installations, that require only annual servicing.

3. A look to the future.

As we move into the next millennium, a review of Australia's approach to antarctic science is appropriate. Australia has an outstanding record of achievement in Antarctica, and we should all be proud of ANARE's history and of our present Antarctic Division. However, the heroic days of Antarctic exploration are over, and what is important now is for Australia to do the best science it can with the available resources. By far the most valuable scientific resource we have in this country is the intellectual vigour of our people—the students, scientists and technical staff at our government institutes, CSIRO and the universities.

To properly make use of this intellectual resource it is essential that an air link be established between Australia and Antarctica. It is no longer necessary to be a hero in order to work in Antarctica, but you do need to be able to get to and from the continent quickly. The realities of current academic life are such that spending weeks on a ship each year is simply impossible for most researchers. Until an air link is established, Antarctica will remain inaccessible to most of Australia's scientists, including many who could make an enormous contribution to our research programs there.

It makes no difference whether this air link is established through international agreement, by leasing ski-equipped Hercules aircraft, or by building a rock runway at Davis. As the US Antarctic Program has shown, involvement of the "mainstream" scientific community in antarctic research is an important factor in the attainment and maintenance of research excellence. This is even more important for a small country like Australia, as we cannot afford not to involve our top researchers in each particular field.

An air capability might also be the most efficient way of servicing an inland base (although tractor-traverse offers a viable alternative). In this way the plateau can be opened up for scientific work—not just for astronomy but glaciology, climatology and meteorite research.

With all of the best potential astronomical sites lying within the Australian Antarctic Territory, a wonderful opportunity now exists for Australia in what will certainly become a major new research area. The development of an international astronomical observatory on the high antarctic plateau is likely to occur in the first few years of the new millennium. Australia is ideally placed to play a leading role in this exciting new development, building upon our traditional strengths in both astronomy and antarctic research.

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