Prospects for an Antarctic Observatory

P. R. Gillingham, *Anglo-Australian Telescope, Coonabarabran NSW 2357*

Abstract: Following a 1989 USA conference on Astrophysics from Antarctica, a number of proposals have been advanced to exploit the great astronomical potential of this region. The most interesting is for an international station at a new site chosen for optimum astronomical performance. Near the highest point of the ice plateau (where the pressure altitude is about 5000 m), the extremely dry cold atmosphere will allow effective observation through many wavelength ranges currently inaccessible from the ground. There is also reason to believe that better seeing than is otherwise obtainable from the Earth's surface may be achievable. Astronomers interested in future Antarctic observing should co-operate in presenting cases to their governments for support facilities there.

1. Introduction

The case for an Australian program to investigate actively the astronomical merits of Antarctic sites and to establish the possibilities for international co-operation was presented to the June 1989 Canberra meeting, 'The Future of Australian Astronomy' (Gillingham 1989). It was argued that, with special provisions, substantially better seeing might be available than at any other ground site. At about the same time, there was a meeting at the Bartol Institute, USA, on 'Astrophysics from Antarctica'. As a sequel to this US meeting, a number of proposals for new astronomical initiatives in the Antarctic have been put forward. The most ambitious calls for the establishment of a permanent astronomical base at a new site chosen for optimum observing conditions at infrared and millimetre wavelengths (see Figure 1). This station (Lynch 1989) would be on the East Antarctic ice sheet at an altitude over 4000 m (with a wintertime pressure altitude of over 5000 m). Reliably based on meteorological measurements at the South Pole, Vostok, and Dome C sites, precipitation would be very low (1 to 5 cm/year), clear skies would predominate, and wind speeds would be low, averaging only about 3 m s^{-1} for the windiest month. The coldest air temperatures would be near −90°!

The proposal for the international high altitude observatory is incorporated in a submission (Stark, Harper *et al.* 1989) to the National Science Foundation to establish a Centre for Astrophysical Research in the Antarctic (CARA). Part of this submission has already been funded: the Antarctic Submillimetre Telescope and Remote Observatory (ASTRO), comprising a 1.7 m diameter unobstructed submillimetre-wave telescope, scheduled for permanent installation at the South Pole in late 1992. Projects planned to follow under the aegis of CARA include an infrared imaging telescope of 60 cm diameter using a 256 × 256 array detector (SPIREX – South Pole Infrared Explorer) and a 3 m diameter telescope to operate in the 2 and 3.3 mm wavelength windows, especially to search for anisotropy in the cosmic microwave background. It is proposed that during operation of these initial instruments, an Advanced Telescope Project group would be formed to plan, for the second half of the 1990s, an Antarctic telescope with significantly greater sensitivity and resolution than the SPIREX and ASTRO instruments. Possibilities mooted, in order of increasing cost, are:

(1) a 10-metre single dish carbon fibre submillimetre telescope
(2) a 30-metre submillimetre dish
(3) an 8-metre optical quality telescope
(4) arrays of either submillimetre or optical quality telescopes with interferometric capabilities.

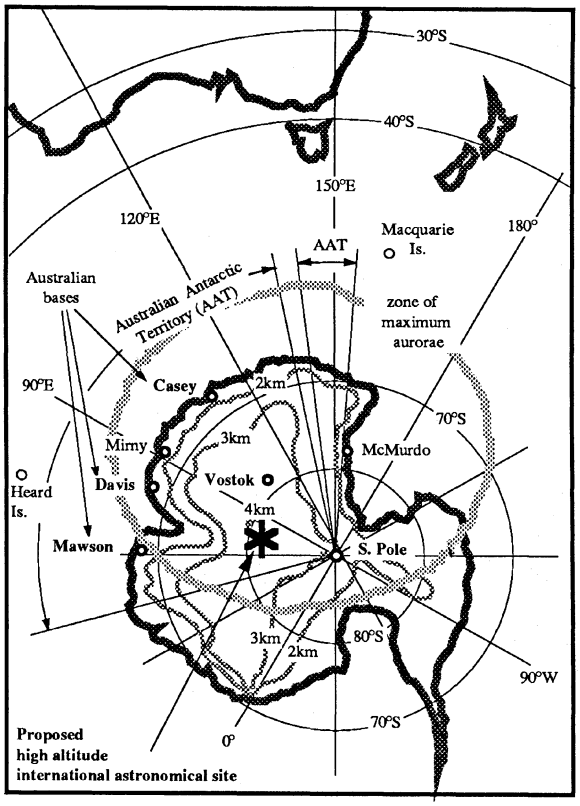

Figure 1 – Map of Antarctica showing some existing bases and the most likely site for the new international astronomical observatory.

2. Attractions of a High Altitude Antarctic Site

Gillingham (1989) dealt in some detail with the advantages to astronomy of an Antarctic site. These include round the clock viewing, very good access to the Magellanic Clouds (especially noteworthy is the good access to the LMC when it is poorly placed for moderate latitudes, i.e., during the southern winter) and, most remarkably, the extremely dry, tenuous, clean and cold atmosphere.

Measurements from the South Pole (altitude 2835 m) of microwave background and infrared transmission (Pomerantz 1986) and detailed calculations of the atmospheric transparency to be expected over Antarctica for wavelengths from 20 μm to 1 mm (Bally 1989) show the great gains offered, even in relation to a site like Mauna Kea. At 4000 m altitude, water vapour column densities less than 0.1 mm should not be uncommon. Many new windows open at wavelengths below 100 μm.

In the near infrared band between 2.27 and 2.45 μm, which is free of OH airglow emission (Stark, Harper *et al.* 1989), the net background flux may approach the limit set by the zodiacal light. Since the zodiacal light has its minimum spectral intensity in this wavelength range, the background radiation would be lower

here than at any other wavelength, including the visible. The recent emergence of very efficient two-dimensional detectors for this near infrared region will present great opportunities in the next decade which could best be exploited in the Antarctic.

The very low temperature of the telescope itself in an Antarctic location (typically lower than that of space telescopes) will also contribute greatly to improved infrared performance.

There are good reasons (Gillingham 1989) to believe that superb seeing, consistently better than is attainable from the best sites used so far, might be achieved at an Antarctic site with suitable provisions. Seeing degradation is the result of air temperature inhomogeneity, which is largely a by-product, at most sites, of the diurnal temperature variation. In the Antarctic, especially in winter, there is negligible systematic diurnal temperature variation. But near the ground, which reaches a lower temperature than the adjacent air, a strong inverse temperature gradient is established which, in conjunction with even light wind, leads to considerable temperature fluctuation for many metres above ground, on time scales of a few hours. So to achieve the best seeing, it may be necessary to elevate a telescope well above the surrounding terrain. Whether the required elevation is as much as, or maybe more than, 100 metres can probably be determined only by careful measurement at the proposed site or at similar sites already established.

3. Favourable Portents for Astronomy in the Antarctic

The fact that several US proposals have come to the fore in the last year or so, together with the specific references in some of these proposals to the desirability of international collaboration, should be very encouraging to astronomers of other nations. Australia, with its southern latitude, its long-established bases and experience of scientific work in the Antarctic, is particularly well placed to contribute to and share in the benefits of an observatory there. The most favourable location for the new astronomical base is at or near the highest point of the East Antarctic ice plateau. This would place it about equidistant (roughly 800 km) from the US base at the South Pole and the Soviet base, Vostok. The greatly changed political scene must now favour US–Soviet collaboration in such a project.

Politically, logistically and scientifically, a very high altitude Antarctic observatory would be an ideal precursor to the moon-based observatory which is now being discussed quite seriously and which is bound to be established early in the 21st century.

The Australian Antarctic Science Advisory Committee (ASAC) has been requested by the responsible government Minister to review and report on aspects of the science program being conducted by Australia in Antarctica. A submission covering the topics discussed in this paper is being lodged with the review sub-committee.

4. Recommendations for Promoting an International Antarctic Astronomical Observatory

Efforts will be made to schedule discussion of the plans for an international Antarctic observatory at the IAU General Assembly in July 1991. Assuming the outcome result of this discussion is positive, the IAU should use its good offices to promote the project.

Pending a decision to proceed with an observatory at a site ideal for astronomy, the co-operation of the Australian, US, and Soviet Governments (at least) should be sought in setting up tests at the South Pole station and at Vostok which will show the likelihood of, and the special provisions needed for realisation of, unmatched seeing at any new site. (Other advantages of the proposed site, especially the good transmission and low background in the infrared and millimetre wavelengths, have been well recognised in the US proposals and their improved quantification will follow from these proposals).

Bally, J., 1989, 'Atmospheric Transparency over Antarctica from the Mid-infrared to Centimeter Wavelengths', presented to Bartol Conference on Astrophysics in Antarctica, Delaware, June, 1989, (to be published in the meeting's proceedings).

Gillingham, P. R., 1989, 'Antarctic Optical-Infrared Observatory', presented to meeting on the Future of Australian Astronomy, organised by ASA for Australian Science and Technology Council, Canberra June, 1989, (not published but copy available from AAO).

Lynch, J. T., 1989, 'A Proposal for an International Station in Antarctica' presented to Bartol Conference on Astrophysics in Antarctica, Delaware, 1989, (to be published in meeting proceedings).

Pomerantz, M. A., 1986, 'Astronomy on Ice', *Proc. Astron. Soc. Aust.*, 6, 403.

Stark, A. A., Harper, A. *et al.*, 1989, 'Proposal for a Center for Astrophysical Research in Antarctica', submitted to National Science Foundation, Science and Technology Centers Program, August, 1989.