Programme for STAR/SCAR XXIII Workshop on Antarctic Astronomy

Monday, August 29, Rome, Italy

Organised by D.A. Harper (U. Chicago / CARA) and M.G. Burton (UNSW / JACARA)

Session 1	Chair: Storey	
09:00	J. Dudeney (BAS, UK)	Opening Remarks on behalf of STAR
09:20	M. Burton (UNSW, Australia)	The Scientific Case for Antarctic Astronomy
09:50	D. Harper (Chicago, USA)	CARA – The Center for Astrophysical Research in Antarctica: Progress and Prospects
10:20	Break	
Session 2	Chair: Stark	
10:50	P. Buford Price (UC Berkeley, USA)	AMANDA: The Antarctic Muon and Neutrino Detector Array
11:15	M. Hereld (Chicago, USA)	CARA: SPIREX – The very latest news
11:45	G. Sironi (Milano, Italy)	Observations of the CBR from Antarctica
12:05	J. Peterson (Carnegie–Mellon, USA)	CARA: Millimeter Cosmology
12:30	Lunch	
Session 3	Chair: Harper	
14:00	G. Dall'oglio (Roma, Italy)	Italian Astronomy Plans for Dome C
14:20	A. Stark (Harvard, USA)	CARA: Progress Report on AST/RO
14:40	K. Maslennikov (Pulkovo, Russia)	Russian Plans for Antarctic Astronomy
14:55	J. Vernin (Nice, France)	Optical Turbulence at the South Pole: First Measurements and Future Plans
15:10	M. Mosconi (Cordoba, Argentina)	An Astronomical Observing Site at 78° South
15:25	J. Hough (Hertfordshire, UK)	UK Activity and Interests in Antarctic Astronomy
15:40	Break	
Session 4	Chair: Burton	
16:10	M. Dopita (MSSSO, Australia)	The International Antarctic Balloon Observatory
16:30	P. Bely (STSCI, ESA/USA)	The Polar Stratospheric Telescope
16:50	J. Storey (UNSW, Australia)	Low-Power Site Testing Instruments for Antarctica
17:10	R. Loewenstein (Chicago, USA)	CARA: Future Communications Needs for Antarctic Astrophysics
17:30	Open Discussion	Developing Astronomy in Antarctica
18:15	Close	

The Scientific Case for Antarctic Astronomy

Michael Burton
University of New South Wales, Sydney, Australia

The limiting factor affecting the performance of astronomical observatories in many wavebands is now the quality of the site being used to conduct the observations. Considerable resources are being devoted worldwide to optimizing the returns from the best available sites. The Antarctic Plateau, with its combination of extremely cold, dry, tenuous, and stable atmospheric conditions, has the potential of being the best site on the surface of the planet for the conduct of many types of astronomical observations.

The scientific potential is tremendous; new windows opening up in the infrared and submillimetre bands, background levels reduced to the zodiacal limit itself in the near-infrared, superb seeing in the optical and the near-infrared, interferometry in the submillimetre and millimetre, neutrino, gamma-ray and cosmic-ray telescopes in high-energy astrophysics, for example.

Our challenge is to construct facilities that can undertake such observations in the harsh environment, perhaps even at a new inland station such as the high points of the Plateau, Domes Argus and Circe. It will be many years before we can expect to build the largest scientific facilities there. In the meantime, however, there are many areas of astrophysics where significant advances can be made with modest facilities, taking particular advantage of the unique conditions of the Plateau for astronomy. These areas involve near-infrared and submillimetre astronomy. Scientific cases for the development of Antarctic astronomy should be aimed squarely in these niche areas for the present.

The Australian Working Group for Antarctic Astronomy recently completed a detailed report on the scientific potential of the Plateau. This paper will describe the findings in this report, and outline some of the activities being undertaken by Australia to develop this potential. The Joint Australian Centre for Astrophysical Research in Antarctica has recently been constituted to achieve these aims.

CARA—The Center for Astrophysical Research in Antarctica: Progress and Prospects

D. A. Harper
University of Chicago/CARA, USA

Scientists have recently begun several major initiatives to capitalize on the unique atmospheric, climatic, and geographical advantages of the Antarctic Plateau for astrophysical experiments. If these ventures are successful, Antarctic telescopes may become premiere tools for a broad range of Earth-based astronomical observations during the twenty-first century.

AMANDA: The Antarctic Muon and Neutrino Detector Array

P. Buford Price
University of California, Berkeley, USA

AMANDA, now under construction, will give birth to the new science of high-energy neutrino astrophysics. The concept is to detect high-energy neutrinos that are emitted from powerful sources throughout the universe and that penetrate the Earth. A fraction of these neutrinos are converted into a high-energy muon, which is detectable by its Cherenkov light. A three-dimensional array of photomultiplier tubes implanted in the deep ice at the South Pole will look downward and record the arrival times of photons in the Cherenkov cone, enabling the direction of the muon to be determined.

During the 1993-1994 austral summer we succeeded in drilling four holes, 60 cm in diameter, to a depth of 1 km, and we deployed 20 large phototubes in each of the holes. The tubes survived refreezing of the ice, and almost all of the tubes are functioning perfectly. Signals from the tubes, which are spaced 10 m apart on each string, are transmitted along cables to electronics at the surface. To complete the present array, six strings will be deployed at a depth of $\sim$ 1600 m, which together with the first four strings, will form a pyramid with an effective collecting area of several tens of thousands of square meters. The data from the first four strings show that the ice has an unexpectedly large attenuation length of 60 m for visible light. Despite the fact that residual air bubbles at a 1 km depth scatter the light from muons, it will be possible with the first four AMANDA strings, in conjunction with the SPASE surface air-shower array directly above AMANDA, to study the composition of ultrahigh-energy cosmic rays. At their greatest depth, the next six strings will not encounter bubbles and will be able to observe unscattered Cherenkov light.

CARA: SPIREX—The Very Latest News

Mark Hereld, Bernard J. Rauscher, Hien Trong Nguyen, Scott A. Severson
University of Chicago/CARA, USA

The South Pole Infrared Explorer (SPIREX) is completing its first year of tests and experimentation. We deployed a 0.6-m telescope and a near-infrared imaging spectrophotometer (GRIM) this past summer. During the winter we have begun a program to monitor and characterize the sky brightness over the Pole at near-infrared wavelengths, observed the recent series of collisions of comet Shoemaker-Levy 9 with Jupiter, and performed tests on the hardware.

Observations of the CBR from Antarctica

G. Sironi and G. Bonelli
Dipartimento di Fisica dell' Universita - Milano, Italy
Instituto di Fisica Cosmica del CNR - Milano, Italy

We are currently searching for spectral distortions (deviations from a Planckian distribution) at low frequencies ($\nu \sim 1$ GHz) and residual polarization of the Cosmic Background Radiation taking advantage of the special conditions (atmospheric transparency, low level of radio interferences) one can find in Antarctica.

Results of previous campaigns carried out at South Pole and programs for new observations from the Italian base at Terra Nova Bay and the Plateau above it are presented.

CARA: Millimeter Cosmology

Jeffrey B. Peterson
Carnegie-Mellon University, USA

Near one millimeter wavelength a deep minimum in the emission of the Galaxy provides an opportunity to make cosmological observations that are not possible at other wavelengths. A 10-m aperture telescope optimized for these wavelengths on the Antarctic plateau would make possible several new kinds of cosmological observations, including small-scale cosmic background anisotropy measurements, studies of the Sunyaev-Zel'dovich effect in galactic clusters, detection of emission by dust in galaxies at high redshift, and detection of emission by high-redshift galaxies of the 158μm fine structure line of C^+.

CARA: Progress on the Antarctic Submillimeter Telescope and Remote Observatory (AST/RO) Project

Antony A. Stark
Smithsonian Astrophysical Observatory, USA

AST/RO is a 1.7-m diameter submillimeter-wave radio telescope scheduled to begin operations at the Amundsen-Scott South Pole station in December 1994. Site testing shows that the South Pole has exceptional submillimeter-wave sky transparency and stability. Trial observations have been carried out at Boston University over the past two years; the AST/RO is fully operational. A 230 GHz SIS receiver and a U. of Cologne acousto-optical spectrometer with 2048 channels in a 1.2 GHz bandwidth have been used to collect several hundred test spectra, many of which are essentially perfect within the noise. A U. of Illinois 492 GHz SIS receiver with 160 K DSB noise temperature and a Radiometer Physics GmbH 492 GHz Schottky-barrier diode receiver have also been installed and partially tested. Absolute pointing is 10 arcsec rms. Scans of the Sun show that the offset optics provide a Gaussian diffraction-limited beam.

Russian plans for Antarctic Astronomy

Kirill Maslennikov
The Central Astronomical Observatory
Russian Academy of Sciences

The Russian science community (and astronomers in particular) have far-reaching intentions for developing activities in Antarctica. In spite of the present crisis state of Russian economy it is hardly possible that the vast totality of experience accumulated by Russian investigators in Antarctica could be lost without use. The present activities of Russian astronomers in the area of Antarctic astronomy are concentrated under the coordination of the Astronomical Society of Russia. In its frame the working group was formed in 1991 (chairman: Dr. V. Burdyuzha). The most involved institutes are:

- The Astro-Space Center, Lebedev Physical Institute, Moscow;
- The Space Research Institute, Moscow;
- The Central Astronomical Observatory, Pulkovo, St.Petersburg;
- The Arctic and Antarctic Institute, St.Petersburg.

Here is a brief summary of the activities in this field:

1. The preliminary project of the International Antarctic Observatory was developed (and reported by Dr. Burdyuzha at IAU General Assembly in Buenos-Aires). Now the further development of the project is to be performed involving military industrial enterprises which are converted to the scientific and civil production.
2. The Soviet Antarctic Vostok base supplied the vast body of climate and meteorology data for more than 30 years. Particularly the temperature distributions with height were being obtained almost daily thus defining the structure function and seeing parameters. These data are now under processing. The Vostok base is now conservated but is being restored to use in a few months. Its position seems very accessible due to the height (3480 m) and proximity to Dome A. Another basepoint, the 3800 m Komsomolskaya, might be even more promising.
3. There are now three instruments being modified and winterised for operations in Antarctica:
   - IR-hygrometer tested at Vostok base and destined to site testing;
   - submillimeter photometer based on the one used at Pamir base of Pulkovo Observatory at 4300 m above the sea level under severe winter conditions;
   - IR–photometer / polarimeter (0.3–3 microns) designed at Pulkovo Observatory.

Optical Turbulence at South Pole: First Measurements and Future Plans

J. Vernin, M. Azouit, J. F. Manigault
Université de Nice, France
R. Marks, M.C.B. Ashley, M. G. Burton
University of New South Wales, Australia
and J. W. Briggs
CARA, USA

First optical turbulence measurements inside the polar surface layer are presented here, which show that surface layer (7–27 m above ground) turbulence has a very weak contribution to astronomical image degradation. Measurements have been carried out at South Pole, during the polar night, with microthermal sensors attached at three levels on a 27 m high mast. Our future plans are to check the rest of the atmosphere (30 m up to 30 km) with free flight instrumented balloons, during the 1995 winter-over at South Pole.

An Astronomical Observing Site at 78 Degrees South

Pablo Recabarren and Mirta Mosconi
Observatorio Astronomico de Cordoba, Argentina

We describe astronomical Antarctic activities during 1989 and 1990 in Argentine Antarctic Station Belgrano, including site testing and the new projects on the installation of a small observing station with an 11-inch reflector with a CCD camera and filters in order to measure atmospheric extinction, variable objects, and solar activity in the Hα band. We also describe all the scientific programs developed there in other areas (upper atmosphere) and the available logistic facilities of this polar station.

UK Interests in Antarctic Astronomy

James Hough
University of Hertfordshire, UK

Although the UK has played little part in the overall developments of astronomy in Antarctica, with the exception of some of the high-energy astrophysics experiments at the Pole, it does recognize the huge potential of Antarctica for many areas of astronomy.

The UK is presently undertaking a major review of its optical / infrared / millimetre astronomy program, and as part of that review it will be looking at new facilities required over the next decade and beyond. Clearly, it will wish to look at the opportunities presented by Antarctic astronomy, and would wish to discuss these with potential partners around the world.

The International Antarctic Balloon Observatory

Michael A. Dopita
Mt. Stromlo and Siding Spring Observatories, Australia

Assuming a successful Australian/US program of site testing at the South Pole and at Dome C (Circe/Concorde), we have proposed the construction, as an international partnership project, of an International Antarctic Balloon Observatory (IABO), to be deployed above the Antarctic high plateau at an altitude of 8–10 km. This observatory facility would be of the 2.5-m class, and would be designed to provide unique imaging capabilities in the visible and near-infrared (the POST concept), or to provide unequaled sensitivity in the far-infrared.

The considerations relating to the choice of observing site are discussed, and some aspects of the infrared mission are emphasized.

POST: The Polar Stratospheric Telescope

Pierre Bely
Astrophysics Division, European Space Agency, STSCI
Holland C. Ford, Richard Burg, Larry Petro, Rick White
STSCI, USA
and John Bally
University of Colorado, USA

The tropopause, typically at 16 to 18 km altitude at the lower latitudes, dips to 8 km in the polar regions. This makes the cold, dry and nonturbulent lower stratosphere accessible to tethered aerostats. Tethered aerostats can fly as high as 12 km and are extremely reliable, lasting for many years. In contrast to free-flying balloons, they can stay on station for weeks at a time, and payloads can be safely recovered for maintenance and adjustment and relaunched in a matter of hours. We propose to use such a platform, located first in the Arctic (near Fairbanks, Alaska) and, potentially, later in the Antarctic, to operate a new technology 6-m, diluted aperture telescope with diffraction-limited performance in the near-infrared. Thanks to the low ambient temperature (220 K), thermal emission from the optics is of the same order as that of the zodiacal light in the 2 to 3 micron band. Since this wavelength interval is the darkest part of the zodiacal light spectrum from optical wavelengths to 100 microns, the combination of high-resolution images and a very dark sky make it the spectral region of choice for observing the redshifted light from galaxies and clusters of galaxies at moderate to high redshifts.

Low-Power Site Testing Instruments for Antarctica

John Storey
University of New South Wales, Sydney, Australia

Preliminary measurements of conditions at the South Pole confirm the expectation that inland sites in Antarctica can provide the best observing conditions on the surface of the Earth for certain types of astronomy. It is now important that we determine which of the possible Antarctic sites is the best, and how much better that site is than other, possibly more accessible sites. A site testing program has therefore been put in place to study conditions at sites remote from human habitation. This program will be carried out as a collaboration between the Australian organization JACARA and the US CARA.

The site testing will be carried out using an Automated Geophysical Observatory (AGO), in which low-power, automated astronomical instruments have been installed. Built by Lockheed under NSF funding, the AGO is an autonomous, self-heated, self-powered laboratory which is deployed by Hercules aircraft and can run unattended for up to a year. Data are recorded on optical disc and recovered at the end of the twelve-month period. The first astronomically instrumented AGO is scheduled for initial testing at the South Pole in 1996, prior to deployment at a remote site.

In this talk the status of the automated site testing program will be reviewed, and designs for possible low-power instruments discussed.

CARA: [Future] Communications Needs for Antarctic Astronomy

Robert F. Loewenstein
University of Chicago/CARA, USA

As large-scale Antarctic astronomical projects such as the Center for Astrophysical Research in Antarctica (CARA) and the Antarctic Muon and Neutrino Detection Array (AMANDA) become operational, it is estimated that data throughputs on the order of a Gigabyte/day and better interactive communication with winter-over personnel will be required.

In recent years the Internet was not available to the Amundsen-Scott South Pole Station; communication consisted of low-bandwidth (1200–2400 bits/sec) transmission over two aging US Satellites (LES 9 and ATS 3), visible at the pole for a total of 9 hours. Communication sessions were non-interactive and typical data throughputs were 2 Mbytes per day.

First attempts to satisfy these communications needs occurred during the 1993-1994 summer season at the South Pole Station. The first usable Internet connection to the South Pole was made in February 1994. The connection continues through this south polar winter using two satellites (GOES 2 and LES 9) with current data rates of 24 Kbits/sec for a total of 9 hours per day and an effective throughput of about 30 Mbytes/day. It is possible to achieve rates up to 512 Kbits/sec on GOES 2 for 3 hours/day and 128 Kbits/sec on LES 9 for 6 hours/day, yielding a total daily theoretical throughput of about 100 Mbytes/day, far short of estimated needs.

The most viable means of providing the necessary bandwidths to the South Polar region is to continue to identify and acquire usage of several existing satellites that have outlived their original purposes. Other possible methods will be discussed.