BICEP: a Cosmic Microwave Background Telescope at the South Pole

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BICEP is a telescope at the South Pole optimized to probe the polarization of the cosmic microwave background (CMB) for a signature of gravity waves from inflation at the beginning of the Big Bang. The instrument was developed by a team of ∼15 physicists and engineers from Caltech/JPL, UC Berkeley, and UC San Diego. With support from the United States Antarctic Program, it was installed in November 2005 in the Dark Sector Laboratory, 800 meters from the geographic South Pole. CMB observations were primarily conducted from February to November with one winter-over scientist at the South Pole Station for refilling cryogens used to cool the bolometric detectors. The team deployed to the site during summer months for instrument modifications and calibration measurements. The unique location allowed us to map the cleanest available 2% of the sky under the best atmospheric condition on Earth at 100 and 150 GHz. We have completed 3 years of successful observations, mapping the CMB polarization anisotropy at degree angular scales with unprecedented sensitivity. Having coincided with the International Polar Year, we have participated in a live webcast with many schools to talk with them about astronomical observations from Antarctica. In 2010, a next generation instrument, BICEP2, will be installed on the existing telescope mount for additional years of deeper survey.

Astronomy in Antarctica: an overview

Michael Burton

UNSW

An overview of Astronomy in Antarctica will be given. This will cover the reasons why Antarctica provides outstanding opportunities for astronomy on account of the special properties of the atmosphere above the continent, as well as some of the scientific possibilities this facilitates. Astronomical activities currently underway in Antarctica will be summarised, including on the high plateau sites of Dome A, Dome C and South Pole, as well as from long duration balloons. This talk will also serve as an introduction to the presentations in this Special Session where these topics will be treated in more detail.

The SCAR Astronomy and Astrophysics from Antarctica Scientific Research Program

John W.V. Storey

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Title: The SCAR Astronomy and Astrophysics from Antarctica Scientific Research Program Author: John Storey A Planning Group has been established within SCAR to create a new Scientific Research Program. Broadly stated, the objectives of Astronomy & Astrophysics from Antarctica are to coordinate astronomical activities in Antarctica in a way that ensures the best possible outcomes from international investment in Antarctic astronomy, and maximizes the opportunities for productive interaction with other disciplines. SCAR AAA will be organised under four "Themes": A. Site testing, validation and data archiving B. Arctic site testing. C. Science goals. D. Major new facilities. Each theme will be directed by a Working Group. An open invitation to participate in one or more of these working groups will be issued during 2009.

Module for observation in polar regions - polar robotic telescope

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The preliminary step of this project was elaborated in the period 2005-2008. The aim of this project was to achieve a robotic telescope adapted to polar environment activity. After performing the technological study containing the main parameters and attaining goals, a study of astroclimate was elaborated using the already obtained data-base and in situ determination at Romanian-Australian scientific polar station Law-Racovita. The module was build following studies, projects - testing the materials and components in Romania. After performing the final tests in Romania, the module is possible to be installed in situ by our scientific associates, after a preliminary training. We studied also a site in Greenland, to test the module in polar conditions without big expenses. Observational results are intended to be stored in data-bases, for analyzing and processing.

Plans for Dome F

Takashi Ichikawa

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Dome Fuji (or Dome F), the second-highest dome of the Antarctic ice sheet is located at an altitude of 3,810 m above sea level in east Queen Maud Land from Japanese Showa Station by about 1,000 km. National Institute of Polar Research Japan (NIPR) has an observation base, Dome Fuji Station, where ice core drilling was carried out in 1995 -2007. As Dome F has been expected to be one of the best astronomical sites in Antarctica, Japanese astronomy group deployed SODAR and 220GHz radiometer for the first time in 2006 and started the astronomical site evaluation at Dome F. After the suspension due to the construction of a new Japanese ice breaker, Shirase, we will resume the site evaluation from 2010 using small infrared and THz telescopes. According to the annual plan of NIPR, a winter-over base will be reconstructed in 2010-2015 at Dome F. Therefore Japanese group has prospects for the future in astronomy. We will present in the paper the results of the site test in 2006, current status of the preparation, and future plans for the astronomy at Dime F.

Astrochemistry and Astrophotonics from Antarctica

Andreas Kelz

Astrophysikalisches Institut Potsdam

Due to its location and climate, Antarctica offers unique conditions to observe in the infrared wavelength regime, where important diagnostic lines for molecules and iones can be found, which are essential to understand the chemical properties of the interstellar medium. In addition to this low IR-background, recent developments in Fiber-Bragg-Grating technology, allow further suppression of the OH-emission lines in the IR. The presentation will outline the proposed Center for Astrophotonics and Astrochemistry in Potsdam, and possible contributions from it to astronomy undertaken at Antarctica.

OBSERVING THE UNIVERSE FROM THE SOUTH POLE

Vladimir Papitashvili

National Science Foundation, U.S.A.

The title of this talk is taken from Martin Pomerantz' autobiography "Astronomy on Ice" published in 2004. A cosmic rays physicist, Martin was the first who realized in 1980s that the U.S. Amundsen-Scott South Pole Station could be an ideal place for astronomical observations because of its high elevation, 6-months long night, and more important - its clearest and driest air on the Earth. In 1991, NSF established the Center for Astrophysical Research in Antarctica at South Pole that produced spectacular astronomical and astrophysical observations over its decade-long lifetime. Since 2001, the South Pole astrophysical observations mainly focused on the Cosmic Microwave Background radiation studies, measuring for the first time the CMB polarization with the DASI instrument in 2002-2003, continuing characterization of the CMB's E-mode polarization with the QUaD experiment through 2005-2007, and currently challenging the B-mode polarization detection with the BICEP small-aperture radiotelescope. A jewel in the crown of this CMB program is a 10-m South Pole Telescope that began the SZE survey of distant galaxy clusters in February 2007. These two projects, BICEP and SPT, are aiming on the background imaging of cosmic extragalactic polarization to identify imprints of primordial gravitational waves generated at the very first moments of the Universe's life, and therefore provide an experimental test of Inflation. The South Pole Station also houses the IceCube Neutrino Observatory - a cubic-kilometer-size array of 4800 photodetectors deployed in deep and clear ice at the depth from 1.4 to 2.4 km. This array is looking for rare neutrino interactions with nuclei in the ice allowing detection of the corresponding Cherenkov emission across the distances of few hundred meters. This allows capturing information on the origin and direction of cosmic neutrinos generated by most violent cosmic events at the edges of the Universe - in active galactic nuclei or near black holes. This facility also aims on detecting neutrinos resulting of the week interaction between dark matter particles. In addition, the U.S. Antarctic Program helps NASA launching Long-Duration Balloons from McMurdo Station, which circumnavigate the Antarctic continent in a few weeks staying afloat for a month or more. Currently NASA is testing the Super Pressure Balloons that are capable of carrying a heavy payload on the high-altitude mission of 100 or more days.

Icecube Neutrino Observatory at the South Pole

Kirill Filimonov

University of California, Berkeley

High-energy neutrinos of extraterrestrial origin are potentially unique probes of the universe. Unlike high energy cosmic rays that are deflected by intergalactic magnetic fields or gamma rays whose range is limited by interactions with the interstellar medium, neutrinos reach the Earth unscathed. IceCube neutrino observatory, the largest particle detector in the world (1 cubic kilometer), is currently being built at the South Pole. IceCube looks down through the Earth to filter out lower-energy particles and uses optical sensors embedded deep in the ultra-clean Antarctic ice to detect high-energy neutrinos via Cherenkov radiation from charged particles produced in neutrino interactions. IceCube attempts to elucidate the origin of the highest energy cosmic rays and probe the most extreme astrophysical accelerators. I will report on IceCube's construction progress and present a summary of the recent results.

STAR FORMATION AT DOME C

Paolo Persi

IASF Roma

In a short time will be in operation at the Italian-French base of DOME C an 80 cm infrared telescope (IRAIT) equipped with a mid-IR camera (AMICA). Given the excellent characteristics of this Antarctic site in the 3-30 μm spectral region, I propose to develope a key project concerning the study of southern star forming regions. This project include the 5-30 μm wide field images of southern dark clouds, he Chamaleon dark cloud complex and the giant molecular cloud NGC 6334. In addition I'll discuss this project in terms of a possible future 2.5m telescope in operation at DOME C.

ARENA, a roadmap for astronomy at the Concordia Station (Dome C, Antarctica)

Nicolas Epchtein

CNRS/UNSA

ARENA (*Antarctic Research, a European Network for Astrophysics*) is a contract granted by the European Commission aimed to draw up a decadal roadmap for the development of Astronomy and Astrophysics at the French-Italian multidisciplinary station CONCORDIA at Dome C in the Antarctic inland. It is a 4-yr effort starting in 2006 that involves 22 agencies, academic laboratories and industrial companies in 7 European countries (Belgium, France, Germany, Italy, Portugal, Spain and UK) and Australia. Four main activities are currently on going, dealing with site quality assessment and data dissemination, top science cases identification, instrumental concept studies, and logistics requirements. In parallel, six working groups are documenting the appropriateness of this unique site to 6 astrophysical areas/techniques. They deal with optical/IR wide-field deep imaging and spectro-imaging surveys, ultra high angular resolution and long baselines optical/IR interferometric arrays, submillimeter wave astronomy, long duty cycles high precision photometric observations, CMB polarization measurements, and high angular resolution solar astrophysics. Their work in each of these areas is threefold, i) identify the most suitable scientific key programmes, ii) define the instrumental concepts required to carry them out, and iii) evaluate the necessary upgrade of the present logistics. The status of their investigations have been presented and discussed along ten workshops and 3 conferences held in the course of the contract (see details in our web site, http://arena.unice.fr). At the last conference, to be held in May 2009, the consortium will review the working group achievements, endorse the final conclusions and make recommendations to agencies for actions in the next coming decade. At the time of the IAU GA, the roadmap will be essentially finalized and I will present its main guidelines.

Future Plans for Dome C

Vincent Coudé du Foresto

Observatoire de Paris

Dome C, on the Antarctic plateau, is home to the Concordia station with a high potential for some types of astronomical observations. This talk will focus on the mid-term (5-10 years) projects that are being considered for this site: they include a diffraction limited 2m class telescope, a submillimeter antenna, and a stellar interferometer.

The PLATO observatory: robotic astronomy from the Antarctic plateau

Michael C. B. Ashley

University of New South Wales

PLATO is a 6 tonne completely self-contained robotic observatory that provides its own heat, electricity, and satellite communications. It was deployed to Dome A in Antarctica in January 2008 by a Chinese traverse team, and is now in its second year of operation. PLATO is operating four 14.5cm optical telescopes with 1k x 1k CCDs, a wide-field sky camera with a 2k x 2k CCD and Sloan g, r, i filters, a fibre-fed spectrograph to measure the UV to near-IR sky spectrum, a 0.2m terahertz telescope, two sonic radars giving 1m resolution data on the boundary layer to a height of 180m, a 15m tower, meteorological sensors, and 8 web cameras. From 2009/10 PLATO will be upgraded to support a Multi Aperture Scintillation Sensor and three AST3 0.5m schmidt telescopes, with 10k x 10k CCDs and 100TB/annum data requirements. Results from 2008/9 will be discussed.

Science for the Antarctic Plateau: what should we do?

Hans Zinnecker

Astrophysikalisches Institut Potsdam

The Antarctic Plateau (Dome C, also Dome A) is emerging as an especially good site for astronomical observations (high, dry, cold, no wind, good free seeing above a certain boundary layer). Over the last few years, several meetings and conferences took place to discuss potential astrophysical science cases for such exceptional atmospheric conditions. I will try to summarize the conclusions of these discussions and present a global vision for Antarctic Astronomy for future optical, near-IR, thermal-IR, and far-IR/submm observations.

Site testing activities on the Greenland Ice Cap

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We present the site testing program initiated on the Greenland Ice Cap at the SUMMIT station, during the International Polar Year. A DIMM was mounted in the SWISS tower, 39 m above the ice level, during a period of 3 weeks in the late Arctic summer. Tracking Polaris, the DIMM obtained continuous seeing measurements, weather permitting. The campaign was hampered by poor weather and most measurements were in the range of 1 arcsec, with values at times reaching 2 arcsec. During short periods, seeing values well below half an arcsec were obtained. The simplest interpretation is that the seeing above the ground layer is not too dissimilar to what is found above the Antarctic plateau, but that the boundary layer during the campaign reached well above the level where the DIMM was located. The strategy for further site testing in Greenland is being re-assessed, due to the impact of the poor weather encountered.

The LUCAS program : detecting vegetation and traces of life in the Earthshine

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6 - Concordia Station, Dome C, Antarctica

The aim of the LUCAS program is to observe chlorophyll and atmospheric molecules in the Earthshine spectrum in order to prepare the detection of life in terrestrial extra-solar planets to be discovered. Actually, observations from Antarctica offer a unique possibility to study the variations of Earthshine spectrum during Earth rotation while various parts of Earth are facing the Moon. Special instrumentation for the LUCAS program was designed and put in the Concordia station in the Dome C. Observations are in progress.

CSTAR telescope and Dome A site testing

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In Jan 2005, Chinese expedition team first arrived in Antarctic Dome A where is widely predicted as a best astronomical site on earth. In order to promote the development of the Antartctic astronomy, especially astronomy in Dome A, Chinese Center for Antartic Astronomy (CCAA) was founded in 2006. With two years hard work at Dome A, many atuomatically operating site testing instruments and science instruments were mounted there at 2008 and maintained this year. This papaer introduces the first Chinese Antarctic telescope for Dome A(CSTAR) which is composed of four identical telescopes,with entrance pupil 145mm and 20 square degree FOV.CSTAR is mainly used for variable stars detection, measurement of atmosphere extinction, sky background and cloud coverage. It has observed automatically for about 150 days last year and restarted after refurbishing this year.

Robotic supporting for LAMOST-type focal plane on Antarctic plateau

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More and more studies show that there are significant advantages for the antarctic plateau to carry out astronomical research on optical and near infrared astronomy. Best natural seeing on earth, easier adaptive optics seeing correction, seismic-free continent, negligible artificial light pollution and half-year-long night for observing are the good reasons for astronomers and instrument experts to consider telescope plan for that place. LAMOST-type telescope is a kind of special reflecting Schmidt telescope which solved the problem to achieve both wide FOV and large aperture on one Schmidt telescope. Its main optical axis is on the meridian plane with a 25 degrees inclination to the horizontal. The spherical primary mirror is fixed on the foundation and the corrector is composed of deformable, segmented plane mirrors. The focal plane is a spherical cap formed by thousands of fibers, which are accommodated on the focal plate and linked to spectrographs simultaneously. According to the operation configuration, the focal plate has three motions to perform: derotating to compensate the image rotation in the field of view, tilting a certain angle about the focus in the meridian to get best image quality when observing different sky area, focusing along light axis to compensate the thermal influence on the mechanical structure. For the Chinese 4m LAMOST, the accuracy of these three motions are: image field derotation 0.45 arcsec, attitude adjustment 0.24 arcsec, focusing 2 microns. These three motions were realized separately by friction drive, worm gear drive and ball screw drive. Under normal circumstances, it is a hard job to transport, install, and adjust the focal plane mechanism on the site, let alone to build this 36 tons structure on antarctic plateau. Basing on this situation, a kind of robotic supporting structure is proposed in this paper to meet the above three motion requirements and antarctic plateau terrible environment. The three motions will be realized by only one robotic structure, not three separate driving units as 4m LAMOST. Using this kind of robotic supporting, the weight and then cost will be reduced largely and the structure is very compact to reduce the obstruction effectively. It is also helpful to the transportation, installation and adjustment at antarctic environment.

CSTAR and Future Plan for Dome A

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The first Chinese Antarctic telescope CSTAR consisted of four 14.5cm wide field telescopes are installed at Dome A during the traverse in 2007/2008. They successfully have been operated for 135 days. The second project AST3 with three 50cm aperture telescopes with wide field are going to be completed and deployed at Dome A in the following 3 years. As Kunlun Station have been build successfully in Jan. of this year, for the future plan, a larger optical/infrared telescope and a sub-millimeter telescope have been proposed for the future.

The Stratospheric TeraHertz Observatory (STO)

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The Stratospheric TeraHertz Observatory (STO) is a NASA funded, Long Duration Balloon (LDB) experiment designed to address a key problem in modern astrophysics: understanding the Life Cycle of the Interstellar Medium (ISM). STO will first survey a section of the Galactic plane in the dominant interstellar cooling line [C II] (158μm) and the important star formation tracer [N II] (205μm) at $\sim$1 arc minute angular resolution, sufficient to spatially resolve atomic, ionic and molecular clouds at 10kpc. Our mission goals for this survey are to:

1) Determine the life cycle of Galactic interstellar gas.
2) Study the creation and disruption of star-forming clouds in the Galaxy.
3) Determine the parameters that affect the star formation rate in the galaxy.
4) Provide templates for star formation and interstellar feedback in other galaxies.

To achieve the angular resolution requirement STO will have an 80 cm aperture. In order to discriminate clouds in a given beam and determine their distance from Galactic rotation, STO will utilize a heterodyne receiver system with a resolving power, R > 10^6 . The first flight receiver will consist of eight, phonon-cooled HEB mixers; four optimized for the [CII] line and four for the [NII] line. The STO spectrometer will have sufficient bandwidth to detect all clouds participating in Galactic rotation in each of the 8 pixels. STO is capable of detecting every giant molecular cloud in the Galaxy, every HII region of significance, and every diffuse HI cloud with $A_V > 0.3$. Once the [CII] and [NII] surveys are completed, we will propose to use STO to perform complementary surveys in emission lines of [OI], HD and the other [NII] (122μm) line.

In our talk we will further discuss STO's scientific goals, technical approach, and schedule.

Astronomy at the Belgrano Argentine Antarctic Base

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We show the results of the analysis of seeing and extinction data, taken during four years at the Belgrano Station at 77d 52' S - 34d 37'. Data were taken in order to determine the possibilities of the site for astronomical observations. Measurements of seeing and extinction were made with an 11" Schmith-Cassegrain reflector with UBVR filters. The Institute of "Astronomía Teórica y Experimental" has gained extensive experience in site testing over the past years in search of the ELT site in northwestern Argentina. The group is interested in continuing to work in Antarctic astronomy in the future.

The 10 meter South Pole Telescope

John E. Carlstrom

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The South Pole Telescope (SPT) is a 10-meter submm-wave telescope optimized for large-field imaging of low contrast emission, such as the cosmic microwave background (CMB). The telescope was deployed during the 2006-2007 austral summer. The first key project of the SPT is a large area survey to find galaxy clusters using the Sunyaev-Zel'dovich effect, a small spectral distortion in the CMB caused by inverse Compton scattering of the background photons off the hot intracluster gas. Combined with optically determined redshifts, the SZ survey yields will be used to place constraints on the nature of dark energy, via its effect on the growth of clusters and the geometry of the universe. Working toward this goal, the SPT has so far surveyed a few hundred square degrees at high sensitivity. This talk will review the SPT, with emphasis given to aspects of its design which are optimized for operation in Antarctica. We will present some of the first SZ results as well as new results on high redshift dusty galaxies.

Solar cycles and supernovae embedded in a Dome F ice core

Yuko Motizuki[1] , Dome F detailed analysis team[2]

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We have recently found signals of past solar cycles and moreover, candidate spikes of two historical supernovae in a depth profile of nitrate ion concentrations in an ice core portion corresponding to the 10th and the 11th centuries (Motizuki, Y., et al., http://arxiv.org/abs/0902.3446). This ice core was drilled in 2001 at Dome Fuji station (Dome F). In this presentation, we will discuss the validity of this result from astrophysical and chemical points of view, and will further present the extension of our work to deeper and shallower depths. It will be shown that all the nine known historical supernovae in our galaxy appear to be recorded in the same Dome F ice core, although careful analyses are required as was done by Motizuki *et al.* for SN 1006 and the Crab Nebula candidate spikes. Special attention is then paid to the uniqueness of the precipitation environments of Dome F, shown from ionic and tritium measurements (*e.g.*, Kamiyama, K., Ageta, Y. & Fujii, Y. 1989, J. Geophys. Res. 94, 18,515). It is discussed that the site of Dome F may be appropriate to catch information of stratospheric atmosphere in which supernova X- and γ-rays are absorbed and induce physicochemical reactions, resulting in an enhancement of nitrogen oxides. Ongoing and future plans on this project will also be mentioned.