

## Antarctic Sciences GPRA Highlights, FY 2004

### AMANDA Team Announces Results From Radically Different Kind of Telescope

Nugget ID: 8784

Antarctic Muon and Neutrino Detector Array (AMANDA) may offer a glimpse into the origins of the highest energy particles in the Universe. More than 40 years after the first ideas for doing neutrino astronomy emerged, the AMANDA team successfully operated a novel telescope that is capable of detecting ghost-like subatomic particles called neutrinos. This is a radical departure from other astronomical telescopes that are designed to collect light.

In the Feb 2003 edition of *Astrophysical Journal*, the international team of scientists described the first search for extraterrestrial sources of high energy neutrinos with a detector consisting of some 300 optical sensors buried one mile deep in the Antarctic ice. AMANDA researchers hope to unlock some of the secrets of the far Universe, such as identifying the sources of cosmic rays and nature of the Dark Matter.

The AMANDA telescope was expanded to more than 600 sensors in January 2000, and the first results from the completed telescope were reported in the *Physical Review Letters* in February 2004. The AMANDA-II team reports the current best upper limits on the flux of muon neutrinos from the northern hemisphere. The neutrino messengers provide complementary information to that acquired by photons and cosmic rays, and thus can constrain certain models of cosmic neutrino production.

In January 2004, the data acquisition of the AMANDA-II telescope was upgraded to provide an even more powerful probe of the heavens. Operation over the next years will, along with the first deployments of the kilometer-scale neutrino observatory IceCube, provide a progressively refined view of the neutrino sky.

J. Ahrens et al., Search for Extraterrestrial Point Sources of Neutrinos with AMANDA, *Astrophys. J.*, 583, 1040, 2003.

J. Ahrens et al., Search for Extraterrestrial Point Sources of Neutrinos with AMANDA-II, *Phys. Rev. Lett.*, 92(7), doi:10.1103/071102, February 2004.

*This work is notable because:*

This work provides new and unprecedented information about the structure and development of the early Universe.

*Goal Indicators:*

I1, T1

*Other Indicators:*

No other indicators apply.

O/D/OPP 2004

*Program Officer:* Vladimir Papitashvili

*NSF Award Numbers:*

9980474

Award Title: AMANDA 2000

PI Name: Robert Morse  
Institution Name: University of Wisconsin-Madison  
PE Code: 5115

0099367

Award Title: Neutrino Astronomy with the High Energy Neutrino Facility at the South Pole  
PI Name: Steven Barwick  
Institution Name: University of California-Irvine  
PE Code: 1643

Entered on 03/01/2004 by Vladimir Papitashvili  
OPP: Approved 03/12/2004 by Altie H. Metcalf  
O/D: Approved for O/D on 03/12/2004 by Altie H. Metcalf

## **Antarctic Geomorphology - Clues to Understanding Mars**

**Nugget ID: 8682**

Research on the periglacial geomorphology of the Dry Valleys region of Antarctica (see 0125330 - PI David Marchant, Boston Univ) is yielding an understanding of climate related processes which shape the land surface. This work has proven valuable to planetary scientists as they work to interpret new high resolution imagery of Mars and work to infer the processes that have shaped that planet's surface. Particularly noteworthy is the issue of possible extensive ground ice just beneath the Martian surface and the fact that the Dry Valleys provide an important region for comparing landforms where surface features and processes of formation can be linked definitively. An excellent example of the Antarctic "terrestrial analog" being used to great advantage in planetary studies is found in a paper "Recent ice ages on Mars" published in Nature v. 426, p. 792-802, Dec 2003.

*This work is notable because:*

IDEAS - A major step forward for studies of Mars was achieved by acquisition of high resolution images from cameras in orbit. But full interpretation of the landforms depends on inferring processes of formation from surface features. Thus, the interpretation of Martian surface features is advanced considerably because of the terrestrial analog work in the Antarctic Dry Valleys as noted above. PEOPLE - public understanding of science is advanced through exposure of this work via the great public interest in Mars. Note - we did not pigeon hole proposals into GPRA nugget areas at the initial award stage, hence the info provided is a retrospective assessment of how we view this award in terms of GPRA.

*Goal Indicators:*

P4, 11

*Other Indicators:*

No other indicators apply.

O/D/OPP 2004

*Program Officer:* Scott Borg

*NSF Award Numbers:*

0125330

Award Title: Collaborative Research: Multiple Isotope Analyses of Soil Sulfate and Nitrate in the Antarctic Dry Valleys

PI Name: David Marchant

Institution Name: Boston University  
PE Code: 5112

Entered on 02/25/2004 by Scott G. Borg  
OPP: Approved 03/01/2004 by Altie H. Metcalf  
O/D: Approved for O/D on 03/01/2004 by Altie H. Metcalf

## Daytime Gravity Waves Observations Over Antarctica

Nugget ID: 8780

Observing and quantifying gravity waves in the polar mesosphere is an important pre-requisite both for understanding vertical energy transfer through the Earth's atmosphere and for incorporating the effects of mesospheric circulation and temperature into global circulation models. The work describes the detection of mesospheric gravity waves using an all-sky OH airglow imager and an imaging riometer operated by the British Antarctic Survey in collaboration with Utah State University and the University of Maryland at the Halley Research Station. This study describes, for the first time, observations of mesospheric gravity waves using an imaging riometer. Fluctuations in ionospheric radio wave absorption are used as a tracer for the gravity waves and hence can be used during daylight. This is particularly important for research into gravity wave forcing of mesospheric temperature at polar latitudes in summer when continuous 24-hour daylight prevails.

Jarvis, M.J., R.E. Hibbins, M.J. Taylor, and T.J. Rosenberg, Utilizing riometry to observe gravity waves in the sunlit mesosphere, *Geophys. Res. Lett.*, 30(19), 1979, doi:10.1029/2003GL017885, 2003.

*This work is notable because:*

This work provides new information about the structure and development of the Earth's middle atmosphere over Antarctica.

*Goal Indicators:*

I1

*Other Indicators:*

No other indicators apply.

O/D/OPP 2004

*Program Officer:* Vladimir Papitashvili

*NSF Award Numbers:*

0003881

Award Title: Riometry in Antarctica and Conjugate Regions

PI Name: Theodore Rosenberg

Institution Name: University of Maryland College Park

PE Code: 5115

Entered on 03/01/2004 by Vladimir Papitashvili  
OPP: Approved 03/01/2004 by Altie H. Metcalf  
O/D: Approved for O/D on 03/01/2004 by Altie H. Metcalf

## Explosive Gas in the Center of the Milky Way

Nugget ID: 8781

The Antarctic Submillimeter Telescope and Remote Observatory (AST/RO) has completed a major survey of submillimeter-wave spectral lines from the center of our Galaxy, recently published in the *Astrophysical Journal Supplements* (*Martin et al.*, 2004). New data from the telescope at the South Pole Station reveals the mechanism for repetitive explosions in the center of the Milky Way.

AST/RO is exceptionally sensitive because the air over the Antarctic Plateau is exceptionally dry: the AST/RO Galactic Center Survey is a large fraction of all astronomical data ever taken in the 330 to 660 micron wavelength band. The sky is opaque at these wavelengths almost everywhere else on the Earth's surface. The survey data were used to compute the density and temperature of molecular gas within 1000 light years of the Galactic Center, revealing a ring of dense gas accumulating around the galactic center. The density in this ring builds up as gas is added from the outer Galaxy, and is now approaching a critical value. As it has in the past, the ring will coagulate into a giant cloud and fall into the Galactic Center, triggering a burst of massive star formation and fueling an explosion from the Black Hole in the Galactic Center. This happens at intervals of approximately 300 million years. The AST/RO survey data were taken during the 2001 through 2003 Austral winter seasons; AST/RO is currently observing some unusual molecular clouds that are falling into the ring of gas.

C. L. Martin, W. M. Walsh, K. Xiao, A. P. Lane, C. K. Walker, & A. A. Stark, The AST/RO Survey of the Galactic Center Region. I. The Inner 3 Degrees, *Astrophys. J. Suppl.*, 150(1), 239-262, 2004.

*This work is notable because:*

This work provides new and unprecedented information about the structure and development of the Milky Way Galaxy center.

*Goal Indicators:*

I2, T1

*Other Indicators:*

No other indicators apply.

O/D/OPP 2004

*Program Officer:* Vladimir Papitashvili

*NSF Award Numbers:*

0126090

Award Title: Continuing Operation of the Antarctic Submillimeter Telescope and Remote Observatory (AST/RO)

PI Name: Antony Stark

Institution Name: Smithsonian Institution Astrophysical Observatory

PE Code: 5115

Entered on 03/01/2004 by Vladimir Papitashvili

OPP: Approved 03/01/2004 by Altie H. Metcalf

O/D: Approved for O/D on 03/01/2004 by Altie H. Metcalf

## Genomics networks for cold-adaptation in embryos of polar marine invertebrates

Nugget ID: 8743

With support from a NSF Faculty Early Career Development Award for marine research in Antarctica, a researcher working at McMurdo Base, Antarctica is investigating the genetic and physiological ability of the Antarctic sea urchin (*Sterechinus neumayeri*) and the sea star (*Odontaster validus*) to grow and develop in sub-zero seawater (-1.8 degrees centigrade) at very low levels of food availability. The project includes an intern program that encourages minority undergraduate and graduate student participation, and provides an opportunity for these students to do research in Antarctica. The results of this work show that Antarctic sea urchins have extremely efficient metabolic pathways for producing proteins, and ongoing studies are investigating the genetic basis for this adaptive mechanism. If a genetic basis is identified, the research will shed light on the ways that other organisms in extremely cold environments with low food levels can survive and reproduce. The project will also provide the foundation for a K-12 education program, and will facilitate the incorporation of environmental genomics into a bioinformatics curriculum that is under development.

*This work is notable because:*

The principal investigator is a new faculty member at his home university and is the recipient of a NSF Faculty Early Career Development Award. The project includes an intern program that encourages minority undergraduate and graduate student participation, and provides an opportunity for these students to do research in Antarctica. The project will also provide the foundation for a K-12 education program, and will facilitate the incorporation of environmental genomics into a bioinformatics curriculum that is under development.

*Goal Indicators:*

P1, P2, P3, P4, P5, I4

*Other Indicators:*

No other indicators apply.

O/D/OPP 2004

*Program Officer:* Marie Bundy

*NSF Award Numbers:*

0238281

Award Title: CAREER: Genomic Networks for Cold-Adaptation in Embryos of Polar Marine Invertebrates

PI Name: Adam Marsh

Institution Name: University of Delaware

PE Code: 5111

Entered on 02/27/2004 by Marie Bundy

OPP: Approved 03/01/2004 by Altie H. Metcalf

O/D: Approved for O/D on 03/01/2004 by Altie H. Metcalf

# Highest Radio Frequency Spectral Line Observed From the Ground

Nugget ID: 8783

Using a radio telescope at the South Pole, researchers have observed the telltale emissions from a molecular component of the Universe at the highest-ever radio frequencies. The emissions, caused by spectral lines from molecules of carbon monoxide in a region of star formation in Scorpius, were observed at a frequency of 1.267 THz, or about one million times higher in frequency than the FM radio broadcast band. The observations were conducted with the Terahertz Receiver with NbN Device, or TREND, receiver installed on the AST/RO telescope at the U.S. South Pole Station. TREND was developed and installed by a team that included the University of Massachusetts, Lowell Observatory, the Smithsonian Astrophysical Observatory, Chalmers University of Technology, the University of Arizona, and the California Institute of Technology. The team is preparing to observe spectral lines at an even higher frequency when they look for emissions from ionized nitrogen at 1.461 THz during the upcoming austral winter.

E. Gerecht, S. Yngvesson, J. Nicholson et al., Deployment of TREND - A Low-Noise Receiver User Instrument at 1.25 THz to 1.5 THz for AST/RO at the South Pole, paper presented at the 14th Intern. Symp. Space Terahertz Technol., Tuscon, AZ, April 2003.

S. Yngvesson, E. Gerecht, J. Nicholson et al., Upgrade to the TREND Laser LO at the South Pole Station, paper accepted for the 15th Intern. Symp. Space Terahertz Technol., April 27-29, Northampton, MA.

*This work is notable because:*

This work provides new and unprecedented information about the structure of the Milky Way, which cannot be obtained with any other instrument.

*Goal Indicators:*

T1

*Other Indicators:*

No other indicators apply.

O/D/OPP 2004

*Program Officer:* Vladimir Papitashvili

*NSF Award Numbers:*

0126090

Award Title: Continuing Operation of the Antarctic Submillimeter Telescope and Remote Observatory (AST/RO)

PI Name: Antony Stark

Institution Name: Smithsonian Institution Astrophysical Observatory

PE Code: 5115

9987319

Award Title: A User Facility 1.5 THz Heterodyne Receiver System

PI Name: Sigfrid Yngvesson

Institution Name: University of Massachusetts Amherst

PE Code: 1218

Entered on 03/01/2004 by Vladimir Papitashvili

OPP: Approved 03/01/2004 by Altie H. Metcalf

O/D: Approved for O/D on 03/01/2004 by Altie H. Metcalf

## New Dinosaurs Discovered in Antarctica

Nugget ID: 7763

In FY04, two independent research groups made dinosaur discoveries in Antarctica. 1) Judd Case (St Marys College of Calif - Awd OPP-0003844) and James Martin (South Dakota Sch of Mines and Mineral Tech - Awd OPP-0087972) discovered a raptor-like theropod from Cretaceous rocks in the Antarctic peninsula. The find is only the second dinosaur from this region and adds considerable information to our understanding of the nature of the ecosystem that existed. At the time, this region was at a high southern latitude. 2) William Hammer (Augustana College, Illinois - Awd OPP-0229698) discovered a pelvis of a sauropod from the Mt Kirkpartick region of Antarctica. The find was in early to middle Jurassic rocks at a site that was at about 65-67 degrees south at the time of burial. The fact that an example of a class of very large dinosaurs was found at such a high southern latitude has important implications to high latitude ecosystems. (e.g. extremes in sunlight existed even though the world was warmer). OLPA has organized a press event for these discoveries that will occur on 26 Feb 2004 in Washington at the Press Club. OLPA has also prepared some excellent graphics that might be useful to illustrate this nugget. Note for below: It has not been a practice to pigeonhole projects under one particular GPRA goal so the category selected below is chosen for the GPRA category to which this particular nugget pertains.

*This work is notable because:*

Very few dinosaurs have been found in Antarctica and every find has the potential to improve our understanding of Mesozoic vertebrate biology. These two finds are important just with the identification of the type of dinosaur but examination in the coming year or two will likely result in important new information about dinosaur evolution. See above also.

*Goal Indicators:*

I1

*Other Indicators:*

No other indicators apply.

O/D/OPP 2004

*Program Officer:* Rama Kotra

*NSF Award Numbers:*

0003844

Award Title: COLLABORATIVE RESEARCH: Evolution and Biogeography of Late Cretaceous Vertebrates from the James Ross Basin, Antarctic Peninsula

PI Name: Judd Case

Institution Name: Saint Mary's College of California

PE Code: 5112

0087972

Award Title: Collaborative Research: Evolution and Biogeography of Late Cretaceous Vertebrates from the James Ross Basin, Antarctic Peninsula

PI Name: James Martin

Institution Name: South Dakota School of Mines and Technology

PE Code: 5112

0229698

Award Title: Vertebrate Paleontology of the Triassic to Jurassic Sedimentary Sequence in the Beardmore Glacier Area, Antarctica

PI Name: William Hammer  
Institution Name: Augustana College  
PE Code: 5112

Entered on 01/26/2004 by Scott G. Borg  
OPP: Approved 03/01/2004 by Altie H. Metcalf  
O/D: Approved for O/D on 03/01/2004 by Altie H. Metcalf

## **Ocean Tides from Satellite Observations**

Nugget ID: 8819

Ocean tides play a significant role in the complex interactions among the atmosphere, ocean, sea ice and floating glacial ice shelves. Tidal currents create turbulent mixing at the bottom of the ice shelf that influences heat transport between the ice shelf and sea water, and can contribute to the creation of rifts for the detachment of tabular icebergs. In fact within the past several years three large icebergs have broken away from the Ross Ice Shelf, and have changed the circulation and ecology of the Ross Sea.

This reconstruction and modeling of the oceanic tides of the Ross Sea is a highly innovative application of satellite-based radar altimeter data and repeat-pass synthetic aperture radar interferometry to study an important problem in a part of the Earth that is difficult to reach, and in an environment where oceanic moorings and data buoys are in constant danger of being crushed. The convergence of satellite ground tracks in high southern latitudes yields a high level of altimetric and kinematic information that has produced a significantly more accurate tidal model for Sulzberger Bay, and has proven that the grounding line – the boundary where the ice sheet no longer is resting on bedrock, but is beginning to float – is three kilometers farther inland from where it had been located by glaciological techniques. This project is laying the intellectual groundwork for assimilating data that will come from future launches of much more capable satellites.

*This work is notable because:*

P2 The analysis of synthetic aperture radar is by its nature international since it requires the coordination and integration of American, European, and Japanese satellite data. I1 and I5 The application of satellite interferometric techniques to oceanographic problems requires the development of creative and innovative techniques.

*Goal Indicators:*

P2, I1, I5

*Other Indicators:*

No other indicators apply.

O/D/OPP 2004

*Program Officer:* Bernhard Lettau

*NSF Award Numbers:*

0088029

Award Title: Ocean Tide Modeling in South Ross Sea Using Interferometric SAR and Radar Altimetry

PI Name: C. K. Shum

Institution Name: Ohio State University Research Foundation  
PE Code: 5113

Entered on 03/03/2004 by Bernhard Lettau  
OPP: Approved 03/12/2004 by Altie H. Metcalf  
O/D: Approved for O/D on 03/12/2004 by Altie H. Metcalf

## **Solar Wind Origins of Magnetic Impulse Events Detected on the Ground**

**Nugget ID: 8797**

Magnetic impulse events (MIEs) at high geomagnetic latitudes provide key evidence for physical processes involved in the transfer of interplanetary energy into Earth's magnetosphere. The precise origin(s) of such events, prominent in geomagnetic data at locations such as the South Pole, has (have) long eluded investigators. A complete list of MIEs was compiled from South Pole data for the years 1995-2002, and their occurrence characteristics analyzed in conjunction with extensive sets of interplanetary data (solar wind plasma and magnetic field). Detailed minimum variance analysis together with simple artificial intelligence software demonstrated that approximately 50% of the MIEs were produced by hot flow anomalies associated with the solar wind in the magnetosheath, with the remaining 50% resulting from a combination of bursty magnetic field reconnection processes at the Earth's magnetopause and, to a lesser extent, impulsive changes in solar wind flow.

R. Kataoka, H. Fukunishi, and L. J. Lanzerotti, Statistical identification of solar wind origins of magnetic impulse events, *J. Geophys. Res.*, 108(12), 1436, doi:10.1029/2003JA010202, 2003.

*This work is notable because:*

This work provides new information about energy transfer processes into Earth's space environment.

*Goal Indicators:*

I1

*Other Indicators:*

No other indicators apply.

O/D/OPP 2004

*Program Officer:* Vladimir Papitashvili

*NSF Award Numbers:*

9818176

Award Title: Polar Experiment Network for Geophysical Upper-Atmosphere Investigations (PENGUIn)

PI Name: Theodore Rosenberg

Institution Name: University of Maryland College Park

PE Code: 5115

Entered on 03/02/2004 by Vladimir Papitashvili  
OPP: Approved 03/12/2004 by Altie H. Metcalf  
O/D: Approved for O/D on 03/12/2004 by Altie H. Metcalf

## **Subglacial Lake Vostok - Tectonic Framework**

Nugget ID: 8683

An aerogeophysical survey conducted over Subglacial Lake Vostok is yielding important information about this unusual environment. The lake is now known to be composed of two major lobes with the deepest part of one lobe being over 1000m of water (beneath 3.5 kilometer of ice). Further work on the geophysical data has yielded important insights to the tectonic setting of this lake (see Geophysical models for the tectonic framework of the Lake Vostok region, East Antarctica, Earth and Planetary Science Letters, v. 216, p. 663-677, 2003). The tectonic framework is important because of implications of things like heat flow and sediment thickness that characterize different tectonic environments and because of the importance of these characteristics to potential microbial communities that could exist.

*This work is notable because:*

IDEAS - This work is unveiling a unique environmental system on Earth that may harbor an ecosystem. PEOPLE - Fusion of the aerogeophysical data set with data collected by Russian scientists has created an unusual opportunity for international collaboration.

*Goal Indicators:*

P2, 11

*Other Indicators:*

No other indicators apply.

O/D/OPP 2004

*Program Officer:* Scott Borg

*NSF Award Numbers:*

9978236

Award Title: Understanding the Boundary Conditions of the Lake Vostok Environment: A Site Survey for Future Work

PI Name: Robin Bell

Institution Name: Columbia University

PE Code: 5112

Entered on 02/25/2004 by Scott G. Borg

OPP: Approved 03/01/2004 by Altie H. Metcalf

O/D: Approved for O/D on 03/01/2004 by Altie H. Metcalf

## **Winter Mesospheric Temperatures Above South Pole May Predict the Spring Antarctic Ozone Hole Size**

Nugget ID: 8779

Mesospheric kinetic temperatures measured above South Pole Station (90° S) during the austral polar winter show significant changes, which have been found to be associated with changes in the size of the polar stratospheric clouds temperature area (PSC-1), vortex area, and ozone hole area later in the austral spring. Linear regression fits show a statistically significant correlation -95%

confidence level-between the mesospheric temperature and the stratospheric dynamic variables.

These results show the sensitivity of the mesosphere to changes in the atmosphere below. Thus, the mesospheric temperatures measured above South Pole provide a quantitative indication of the dynamic scenario upon which the ozone hole chemistry will be played later in the spring. That is, these mesospheric temperatures can be used as a forecasting tool with which some of the stratospheric dynamical variables affecting the area of the ozone hole can be estimated with statistical confidence.G.

Hernandez, Winter mesospheric temperatures above South Pole (90S) and their relationship to the springtime ozone hole size, *Geophys. Res. Lett.*, submitted, January 2004.

*This work is notable because:*

This work provides new and unprecedented information about the structure and development of the Earth's middle atmosphere and ozone hole in Antarctica.

*Goal Indicators:*

P4, 11

*Other Indicators:*

No other indicators apply.

O/D/OPP 2004

*Program Officer:* Vladimir Papitashvili

*NSF Award Numbers:*

0229251

Award Title: Austral High-Latitude Atmospheric Dynamics

PI Name: Gonzalo Hernandez

Institution Name: University of Washington

PE Code: 5115

Entered on 03/01/2004 by Vladimir Papitashvili

OPP: Approved 03/01/2004 by Altie H. Metcalf

O/D: Approved for O/D on 03/01/2004 by Altie H. Metcalf