Balloon-based experiment to measure gamma rays 6,500 light years distant

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The Crab Nebula. Photo courtesy of NASA

Beginning Sunday, September 18, 2011 at NASA's launch facility in Fort Sumner, New Mexico, space scientists from the University of New Hampshire will attempt to send a balloon up to 130,000 feet with a one-ton instrument payload to measure gamma rays from the Crab Pulsar, the remains of a supernova explosion that lies 6,500 light years from Earth. The launch is highly dependent on weather and wind conditions, and the launch window closes at the end of next week.

The Gamma Ray Polarimeter Experiment (GRAPE), which was designed and built at the Space Science Center within the UNH Institute for the Study of Earth, Oceans, and Space (EOS), is an effort to apply a new type of detector technology to the study of celestial gamma rays.

Specifically, the goal of the GRAPE project is to study the polarization of gamma rays from celestial sources. "Polarized" radiation vibrates in a preferred direction, and the extent of that polarization can provide clues to how the radiation was generated, in essence serving as a probe of the source.

Gamma rays, such as those emitted from the Crab Pulsar, are generally produced from the interactions of a highly accelerated beam of subatomic particles – massive ejections of high-energy particles that are thought to take the form of a narrow jet moving outward at nearly the speed of light.

"We think that an accelerated beam of particles is the source of the high-energy radiation from the Crab Pulsar, but the structure of that beam and the mechanism by which the radiation is generated is not entirely clear," says mission lead scientist Mark McConnell, a professor in the SSC and chair of the UNH department of physics.

Detecting gamma-ray polarization can provide astrophysicists with a better understanding of particle acceleration, a ubiquitous and important but poorly understood process that generates radiation and occurs throughout the universe – from Earth's magnetic field (magnetosphere) to pulsars and black holes.

The New Mexico-based flight, which could last as long as 40 hours, is not designed to reach the ultimate goal of the project – to study gamma-ray bursts. Achieving that will require a follow-up flight over Antarctica where the balloon, due to circumpolar winds that occur between December-January, would circle the pole for 30 to 40 days.

Says McConnell, "To study the gamma-ray burst phenomena we need much more time because they occur randomly in the sky at a rate of about once per day and last at most a couple of minutes. So a long flight will be required to measure a number of bursts."

However, McConnell notes, a successful, short-duration demonstration flight should provide the best measurements of the polarization of gamma rays emanating from the Crab Pulsar to date because of the sophistication of the instrumentation – the "polarimeter" detectors developed at UNH – capable of making the difficult measurement.

The GRAPE balloon payload shown during a power-up compatibility test on September 13 at the Columbia Scientific Balloon Facility in Ft. Sumner, NM. The larger vessel contains the GRAPE instrument. The smaller vessel on the right houses the FACTEL test instrument. Photo by Mark McConnell, UNH-EOS.

"We should be doing some very useful science on the Crab Pulsar during this flight and we only need 24 hours to do that," he says.

The concept of GRAPE has been developed at the SSC over the last 15 years and in 2007 the first small-scale demonstration balloon flight took place using a single polarimeter to prove the concept. In its current incarnation, GRAPE uses 16 polarimeters designed and built at the SSC. For a full-scale flight over Antarctica, 32 of the detectors will be used to monitor the sky for radiation from gamma-ray bursts and solar flares.

The upcoming GRAPE flight will also serve as an engineering test for two other UNH experiments that will piggyback a ride on the balloon. The Fast Compton Telescope, or FACTEL, will be flown to see how well it handles the radiation environment at high altitudes in order to assess its design.

FACTEL (an effort led by UNH physics professor Jim Ryan) is based on work SSC scientists and engineers did in helping build the Imaging Compton Telescope (COMPTEL) onboard the 17-ton Compton Gamma Ray Observatory (CGRO) that was put orbit in 1991. FACTEL represents an effort to demonstrate the latest technologies required to produce an upgraded version of COMPTEL, which should be vastly more efficient and produce much sharper imagery.

A second engineering test being performed on this flight, led by research assistant professor Peter Bloser, involves a new type of detector technology known as silicon photomultipliers. These devices are used to read out signals generated by radiation detectors. This represents a new technology that may prove valuable for many NASA space applications.

High-altitude balloons, with a volume of up to 30 million cubic feet (large enough to contain a football field) have been used to carry NASA experiments to the edge of space for more than 50 years. They provide a vastly cheaper and less time-consuming approach than satellite-based missions and afford an excellent opportunity for student research projects. Three physics graduate students are working on the current flight as part of their Ph.D. studies and several undergraduate students have also been involved in the flight preparations.

More information: The launch can be viewed via a NASA live feed at www.ustream.tv/channel/csbf-operations

Provided by University of New Hampshire

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