fast breaking papers - 2010

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David J. Thompson, Jean Ballet, Isabelle Grenier, & Seth Digel talk with *ScienceWatch.com* and answer a few questions about this month's Fast Breaking Paper Paper in the field of Space Science.

Article Title: Fermi/Large Area Telescope Bright Gamma-Ray Source List
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Journal: ASTROPHYS J SUPPL SER, Volume: 183, Issue: 1, Page: 46-66, Year: JUL 2009
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SW: Why do you think your paper is highly cited?

The Large Area Telescope (LAT) on the Fermi Gamma-ray Space Telescope is providing the first new look at the high-energy gamma-ray sky in more than a decade and with unprecedented sensitivity. Because gamma rays are the most energetic form of light, they can only be produced in processes that involve large transfers of energy.

The LAT is observing the extreme facets of the Universe: huge gravitational pulls, intense magnetic and electric fields, jets, shocks that accelerate particles to nearly the speed of light, and energetic nuclei colliding with matter and light are some of the phenomena that produce gamma rays.

The Bright Source List (BSL) is being cited because it summarizes the early results from the LAT survey of the sky. It takes advantage of the LAT's wide field of view (it surveys the entire sky every three hours), high sensitivity, broad energy range, and good resolution to produce the most detailed picture yet of the powerful sources of gamma rays.

SW: Does it describe a new discovery, methodology, or synthesis of knowledge?

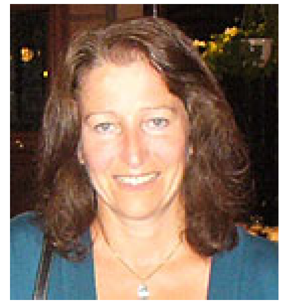
In some respects, the LAT Bright Source List covers all three of these research areas:

1. The list includes many newly discovered astrophysical gamma-ray sources, giving their locations in the sky, with some information about their variability and their energy spectra.

2. The methodology is new, because no previous gamma-ray telescope has had to deal with such a huge region of the sky and such a broad energy range at one time.

3. Synthesis of knowledge is essential in astrophysics, because we always learn the most about a phenomenon by combining knowledge from many different types of observations and with theoretical interpretation.

New types of objects or new aspects of their activity and evolution are found by comparing our gamma-ray data with observations from radio, optical, and X-ray telescopes and then applying models of physical processes to explain these multiwavelength studies.



Top to bottom: Coauthors: Jean Ballet, Isabelle Grenier, & Seth Digel

SW: Would you summarize the significance of your paper in layman's terms?

Trying to understand what is out there in the Universe and how those things work is a bit like the proverbial blind men examining an elephant—different ways of sensing produce different impressions.

What the Fermi LAT Bright Source List does is to demonstrate that gamma rays give us a valuable new way to explore the cosmos, and, in particular, some of the powerful forces that shape the Universe.

For instance, the LAT Bright Source List is dominated by huge black holes that have formed at the centers of galaxies during their cosmological evolution. These black holes are both witnesses and significant actors of the evolution of the Universe to its present state. Their intense gamma-ray emission, produced in jets outside their event horizons, offers a new means to explore their activity over billions of years.

The other sources in the List are found mostly in our own Galaxy. Observing the high-energy side of their activity allows us to explore physical processes that we could not even dream of producing in terrestrial laboratories.

SW: How did you become involved in this research, and were there any problems along the way?

The four of us who are corresponding authors on this paper are just representatives of a large collaboration that built and operates the Fermi Large Area Telescope. In fact, the collaboration is large enough that we produce our major papers with an alphabetic author list (hence, Abdo *et al.*).

We four came from different backgrounds—Dave from the early days of US gamma-ray research at Goddard, Isabelle from the European COS-B gamma-ray telescope collaboration, Seth from radio astronomy, and Jean from X-ray astronomy.

Many others in the LAT collaboration come from particle physics, since the techniques of gamma-ray telescopes are similar to those used in high-energy physics. What brought us together was the opportunity represented by the Fermi Gamma-ray Space Telescope (originally called GLAST).

As with any large satellite project, especially one involving an international collaboration, there were issues (we do not call them problems) of designing the best possible instrument, dividing up responsibilities, finding funding, meeting schedules, and planning for contingencies. We are happy to report that the satellite worked well from the beginning of the mission and is still going strong.

SW: Where do you see your research leading in the future?

The Bright Source List is just a first step for the Fermi mission, which is planned to run for at least five years. As observations continue, we have two outstanding opportunities:

1. The gamma-ray sky is constantly changing, on time scales running from a few hours to many years. The ability of the LAT to monitor the whole sky several times a day enables us to alert observers at other wavelengths of potential targets of interest.

2. As LAT scans the sky, it produces deeper and deeper images of the high-energy Universe. Fainter sources become visible, and greater details emerge of sources already known.

"The Large Area Telescope (LAT) on the Fermi Gamma-ray Space Telescope is providing the first new look at the high-energy gamma-ray sky in more than a decade and with unprecedented sensitivity"

To build the Bright Source List, we have developed and tested the tools and methods necessary to tackle the much larger datasets that are now available. We have also evaluated the pitfalls of such an exercise.

The collaboration has prepared and submitted for publication a fuller catalog with six times more sources that have become visible with data from the first year of the mission.

One remarkable feature of the Fermi mission is the fact that all the data are public. The Fermi Science Support Center at NASA Goddard Space Flight Center in Maryland, USA, provides all the data in near-real-time, along with software so that anyone can look to see whether a favorite object in the sky is producing gamma rays at any given time.

SW: Do you foresee any social or political implications for your research?

It may sound puzzling to think of studying gamma rays coming from distant parts of the Universe as having any social or political implications, but here are several obvious ones:

1. The excitement of exploration. One defining characteristic of humans is the drive to explore. With telescopes like Fermi, we explore the Universe, not by going to distant places but by learning from what comes to us from far away.

When we can tell listeners, for example, that we are seeing millisecond pulsars—stars the size of a city that spin as fast as a kitchen blender—or black holes that gobble and spew matter at bewildering energies—we generate enthusiasm for exploration of all kinds. That sort of excitement translates directly into support for scientific research and education.

2. The challenge of the unknown. Everyone involved in basic research has to deal with the question, "What good is your research?" That question is an opportunity to remind the questioner that even when we have no immediate idea where our research will lead; it may have long-term effects that we cannot

even imagine.

One prominent example is Einstein's general theory of relativity. Surely Einstein had no idea that this work on space and time would prove useful, but anyone who uses a GPS system in an automobile should be aware it would not work if the system did not take general relativistic effects on the GPS satellites into consideration.

3. The importance of interdependence. The more we explore the Universe and its content, the more we see that many phenomena, seemingly independent, are in fact deeply connected.

Interplays between objects or between an object and its environment have played key roles in the evolution of the Universe, whether the object is a planet, a star, or an entire galaxy.

For instance, high-energy phenomena such as exploding stars and black holes have been active in shaping our current Universe. In this context, modern science has to face a great challenge: how to understand with mathematical equations and computers the complexity of these interplays and feedbacks.

This challenge applies to all disciplines, such as cell biology, climate evolution, seismology, or world finances. The Universe is both the simplest and most complex system to explore new methods.

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