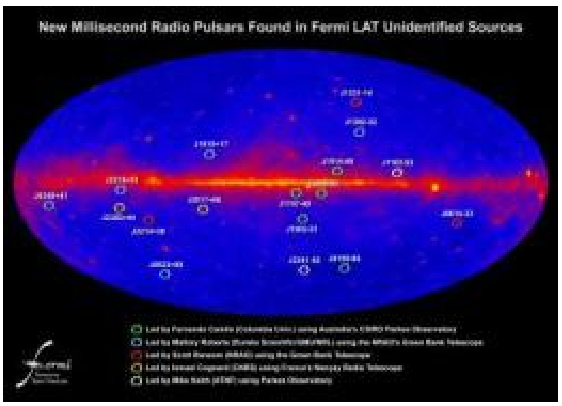
PHYS.ORG

Fermi large area telescope points the way to new millisecond pulsars

January 5 2010



Fermi Large Area Telescope first year map of the gamma-ray sky at energies above 100 MeV with the locations of the new millisecond pulsars shown. The symbols are color coded according to the discovery team: red led by Scott Ransom (NRAO) using NRAO’s Green Bank Telescope (GBT), cyan led by Mallory Roberts (Eureka Scientific/GMU/NRL) also using the GBT, green led by Fernando Camilo (Columbia University) using Australia's CSIRO Parkes Observatory, white led by Mike Keith (ATNF) also using Parkes, and yellow led by Ismael Cognard (CNRS) using France’s Nançay Radio Telescope. Credit: Credit: NASA/DOE/Fermi LAT Collaboration

The discovery of seventeen new millisecond pulsars was announced today at the American Astronomical Society Meeting by scientists from the Naval Research Laboratory (NRL) Space Science Division and a team of international researchers.

The pulsars, discovered in radio searches of unidentified gamma-ray sources found with the Large Area Telescope (LAT) onboard NASA's Fermi Gamma-ray Space Telescope satellite represent a substantial increase in the number of known millisecond pulsars in the disk of our Galaxy and promise a bounty of science yields ranging from the potential direct detection of gravitational waves, to gamma-ray emission mechanisms, to a better understanding of stellar evolution and millisecond pulsar formation. The discoveries are the result of a powerful synergy between gamma-ray and radio observations made possible by the LAT's unprecedented ability to pinpoint gamma-ray sources.

The LAT, the primary instrument on the Fermi satellite, has been surveying the gamma-ray sky since its scientific activation on August 4, 2008. Scientists on the LAT team have been working to identify sources of gamma rays and produce a complete catalog from the first year of observations, consisting of over 1000 sources. A number of these sources were suspected of being hitherto unknown pulsars because they were not coincident with known classes of gamma ray emitting sources and their spectral and variability characteristics were similar to known gamma-ray pulsars.

The LAT first year gamma-ray source catalog is not yet public — its public release is planned for early 2010 — but the Fermi team has produced several interim catalogs for internal use. To make the earliest possible use of these preliminary catalogs, NRL astrophysicist Dr. Paul Ray, an Affiliated Scientist in the LAT collaboration, recruited a handful of radio astronomers with expertise using the largest radio telescopes in the world to form the Fermi Pulsar Search Consortium (PSC). Armed with the Fermi target lists, the observers headed off to their telescopes and started hunting. After searching about 130 targets, and only partially completing the very computationally intensive data analysis, the discoveries have started to pour in, with 17 new millisecond pulsars discovered so far.

Neutron stars are the remnants formed when stars more massive than about 10 of our Suns exhaust their nuclear fuel, exploding in a supernova. With a mass similar to the Sun's but packed into the size of a city, they are the densest objects known. Also known as pulsars, these stars spin rapidly (millisecond pulsars spin hundreds of times per second, faster than a kitchen blender) and emit beams of radiation that can sweep the Earth in lighthouse-like fashion across the electromagnetic spectrum. At one end of the spectrum they are detected by ground-based radio telescopes. At the other end they emit energetic gamma rays, which do not penetrate the Earth's protective atmosphere and can only be detected from space.

Millisecond pulsars (MSPs) are Nature's most precise clocks, with long-term stability that rivals man-made atomic clocks. Precise timing observations of them over periods of years may allow the first direct detection of gravitational waves. Since the first MSP was discovered 28 years ago, countless hours have been spent surveying the sky with radio telescopes and crunching the data with supercomputers, resulting in the discovery of about 60 MSPs in the Galactic disk and more than a hundred in globular clusters. By using these LAT sources as a finding chart and a modest investment in radio telescope time, the team was already able to increase the number of known millisecond pulsars in the disk of our Galaxy by almost 30%!

"By coming together and sharing information, we have been able to accomplish something that neither group could have done on its own. The gamma-ray data are too sparse to allow the discovery of millisecond pulsations from unidentified sources, and the radio discoveries would have been delayed by years if they had to continue surveying the sky without the benefit of the gamma-ray source locations," said Dr. Ray. "And, the back-and-forth continues once the radio observers are able to measure precise orbital parameters and we are able go back to the LAT data to look for the gamma-ray pulses from these sources," he added.

If Einstein's theories, and our understanding of galaxy evolution, are correct then the Earth is constantly bathed in a cacophony of gravitational waves whose presence we never feel. However, by making precision timing measurements of an array of pulsars spread over the sky, it may be possible to detect those waves as a kind of correlated wiggle in the different clocks. This is analogous to Earth-bound gravitational wave interferometers, but with arm lengths measured in thousands of light years, rather than kilometers, and the sensitive frequency range is nanoHertz rather than Hertz. The sensitivity of such an array depends on the quality of the pulsar clocks, the number of pulsars in the array, and how uniform their spatial distribution is on the sky. These new discoveries promise to make a significant improvement in the sensitivity of current pulsar timing arrays.

"For the past couple of years, radio astronomers have been timing hundreds of pulsars, a rather mundane task, in support of the Fermi mission," said NRAO astronomer Dr. Scott Ransom, "and now to be given a treasure map pointing the way to so many exciting new pulsars is a great payback for our efforts." In addition to the gravitational wave detection potential there are four so-called "black widow" pulsars where the powerful wind from the pulsar is blowing away the companion and may eventually destroy it completely leaving an isolated millisecond pulsar behind. These discoveries double the number of such systems known in the Galactic disk and will be crucial for helping understand the evolution of millisecond pulsar systems.

Provided by Naval Research Laboratory