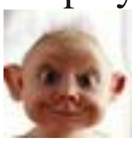
-
- Repost

-

Displaying posts tagged `Crab Nebula`Return
Displaying posts tagged `Crab Nebula`Return
Displaying posts tagged `Crab Nebula`Return



Sigalon's Science & Technology Soup

About

Some Sci/Tech Stuff:

TheFutureOfThings - SciTech Daily - Nature - New Scientist - Popular Science - Scientific American - Science Blogs - EurekAlert - NanoTech/Topix - NanoTechWire - MIT TechReview - MIT News - MIT TechTV - DailyTech - MotlBlog - ScienceDirect - MindHacks - NakedScience - ScienceFriday - RedOrbit - OLED Info - RationallySpeaking- ScribeMedia - Retro/CuttingEdge - H+Magazine- Nanowerk - WiredScience - GizMag - DiscoverMag - SmartPlanet - ScienceMag - BBCScienceInAction - SeedMagazine - NeuralScince -

Search

Accounts

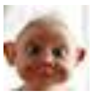
-
-
-
-
-
-
-
-
-

Friends

- My stream
- My TV

Newer posts are loading.
You are at the newest post.
Click here to check if anything new just came in.

February 17 2012



19:54

Crab Nebula’s Pulsar May Be Fast Particle Accelerator

The pulsar at the heart of the Crab nebula. *Image: NASA/HST/CXC/ASU/J. Hester et al*. (high-resolution)

By Matthew Francis, Ars Technica

The Crab Nebula (also designated M1 or NGC 1952) is visible through small telescopes, which has allowed astronomers to observe its growth and evolution since the supernovae that created it became visible in 1054 CE. A pulsar was found in the center of the Crab in 1968. This rapidly rotating neutron star is the core of the star that went supernova to make the nebula. In the intervening decades, x-ray, gamma ray, and radio observations have mapped the region of the nebula closest to the pulsar. During that mapping, it became apparent that the Crab pulsar is one of the brightest sources of gamma rays observable from Earth.

Despite all of those observations, we still don’t fully understand the Crab’s precise gamma ray spectrum, particularly recently observed pulses of intense gamma radiation seen by the Fermi Gamma-ray Space Telescope. Existing models certainly do well at describing much of the complex interplay between the intense magnetic fields of the pulsar and the winds of charged particles flowing outward. But no single scheme seems sufficient to cover *all* the observed phenomena.

A potentially promising new model, proposed by F. A. Aharonian, S. V. Bogovalov, and D. Khangulyan, may fill in some of these blanks. It proposes that areas near the pulsar are acting as rapid particle accelerators, but don't boost electrons and heavier particles to the same extent.

Pulsars are exceedingly small despite their high mass: According to typical neutron star models, the Crab pulsar is approximately 30 kilometers in diameter, but contains nearly double the mass of our Sun. The intense gravitational influence and rapid rotation of pulsars place them firmly in the realm of relativity, while intense magnetic fields carry the enormous amounts of energy we typically encounter in particle accelerators.

In the region immediately surrounding the Crab pulsar, there is enough energy to produce pairs of electrons and positrons, which flow outward into the surrounding gas. This total flow is the *pulsar wind*, a plasma (an electrically neutral substance consisting of separate positive and negative charges) that moves very close to the speed of light.

Close to the pulsar, most of the energy in the pulsar wind is in the form of electromagnetic energy from the pulsar itself. Further out, the energy is mostly in the form of the kinetic energy of the fast-moving plasma particles. How this transition occurs is not completely clear; in particular, it's difficult to square with the 2011 observations of intensely energetic gamma ray pulses.

Though gradual acceleration of the plasma throughout the entire region of interest (a common explanation) is consistent with the behavior of the pulsar wind, gradual acceleration fails to explain the gamma ray signature, which spikes several orders of magnitude higher than the energy from emissions by the pulsar itself. The new model suggests that acceleration of the pulsar wind is rapid, and leaves electrons within the wind moving at roughly the same speed as heavier particles.

What's a light cylinder?

A light cylinder exists for anything that rotates. It contains the volume within a distance that relates the speed of rotation to the speed of light. At the edge of the light cylinder, an object would have to move at the speed of light to maintain an orbit that keeps it over the same location on the rotating body.

An analogy is useful: Imagine a playground merry-go-round that goes around once every minute. If you run around the merry-go-round so that you also complete a circle in one minute, you could probably walk fast enough if you're five feet away. But you'd have to walk much faster for larger circles. If your circle is large enough, you'd have to run at the speed of light: That's the light cylinder for the merry-go-round.

The electrons and positrons driving the pulsar wind are generated in the region around the *light cylinder* of the Crab pulsar. The energy present in the light cylinder of a pulsar comes from its intense electromagnetic fields, which carry away rotational energy from the neutron star.

The Aharonian-Bogovalov-Khangulyan model, published in *Nature* on Feb. 15, argues that the electron-positron plasma cannot be moving very rapidly close to the pulsar, since too much of the energy there is electromagnetic. But the plasma's kinetic energy increases rapidly as it's accelerated away. The pulsar is emitting gamma rays, as mentioned previously; those photons collide with the electrons, transferring energy and momentum in a process known as inverse Compton scattering. This speeds up the wind. By the time the wind has reached a distance roughly 30 times the radius of the light cylinder, the energy balance shifts so that almost all of the energy is in the wind, with acceleration occurring very rapidly in a narrow region.

Among the side effects of this acceleration is a spike in gamma ray emission, due to the fact that the wind is revolving around the pulsar as well as streaming outward. (Charged objects that curve through a magnetic field emit radiation to balance their energy books.) In this model, these emissions ensure that many of the electrons are moving at nearly the same speed as the protons within the plasma, which is not typical behavior: Protons are much harder to accelerate due to their much larger mass.

If gradual rather than abrupt acceleration occurs, there would be more gamma rays produced than appear in the spectrum according to the researchers' calculations. Similarly, if the region of acceleration is moved either farther from or closer to the Crab pulsar, the telltale gamma ray spikes also move and change shape. In other words, while the general picture is motivated by underlying physics, the specific details of the model are determined by adjusting parameters to make the spectrum fit the data.

Therefore, it should be emphasized that this is at present a plausible model for the production of high-intensity gamma ray pulses. As the authors recognize, further observations are needed to settle whether the pulsar wind acceleration and region of gamma ray production corresponds fully to what they propose. Nevertheless, enough concrete predictions are made by this model to compare to alternative explanations for the gamma ray spectrum, so additional data should be able to resolve which — if any — of the proposed theories truly explain what is seen in the Crab Nebula.

Citation: "Abrupt acceleration of a 'cold' ultrarelativistic wind from the Crab pulsar." By F. A. Aharonian, S. V. Bogovalov and D. Khangulyan. Nature, published online Feb. 15, 2012. DOI: 10.1038/nature10793

Source: Ars Technica

Tags: Physics Space Ars Technica astrophysics Crab Nebula gamma rays neutron star particle accelerators pulsar

- #
-
- React

May 12 2011

20:13

Crab Nebula Spews Most Powerful Flares Yet

The latest and greatest outbursts from the Crab Nebula — long known for its steady high-energy glow — are challenging theories about how the heavens accelerate charged particles to high energies.

ScienceNews
MAGAZINE OF THE SOCIETY FOR SCIENCE & THE PUBLIC

Only last year, scientists were astonished to find that the nebula — a giant cloud 6,500 light-years from Earth with the spinning cinder of an exploded star at its center — had spat out gamma-ray flares that fluctuated on time scales of only a few days (*SN: 1/1/11, p. 11*).

Last month, however, the nebula outdid itself, says Rolf Buehler of the SLAC National Accelerator Laboratory in Menlo Park, Calif. The Crab hurled gamma-ray flares, more energetic and five times brighter than any previously recorded, that fluctuated over just one to three hours. Buehler announced the findings, based on observations with the Fermi Gamma-ray Space Telescope, on May 11 in Rome at the annual Fermi symposium. A second team observed the April fireworks with AGILE, another orbiting telescope.

“These recently discovered flares indeed present a new set of challenges and highlight our ignorance of how this fascinating [object] works,” comments theorist Dmitri Uzdensky of the University of Colorado at Boulder.

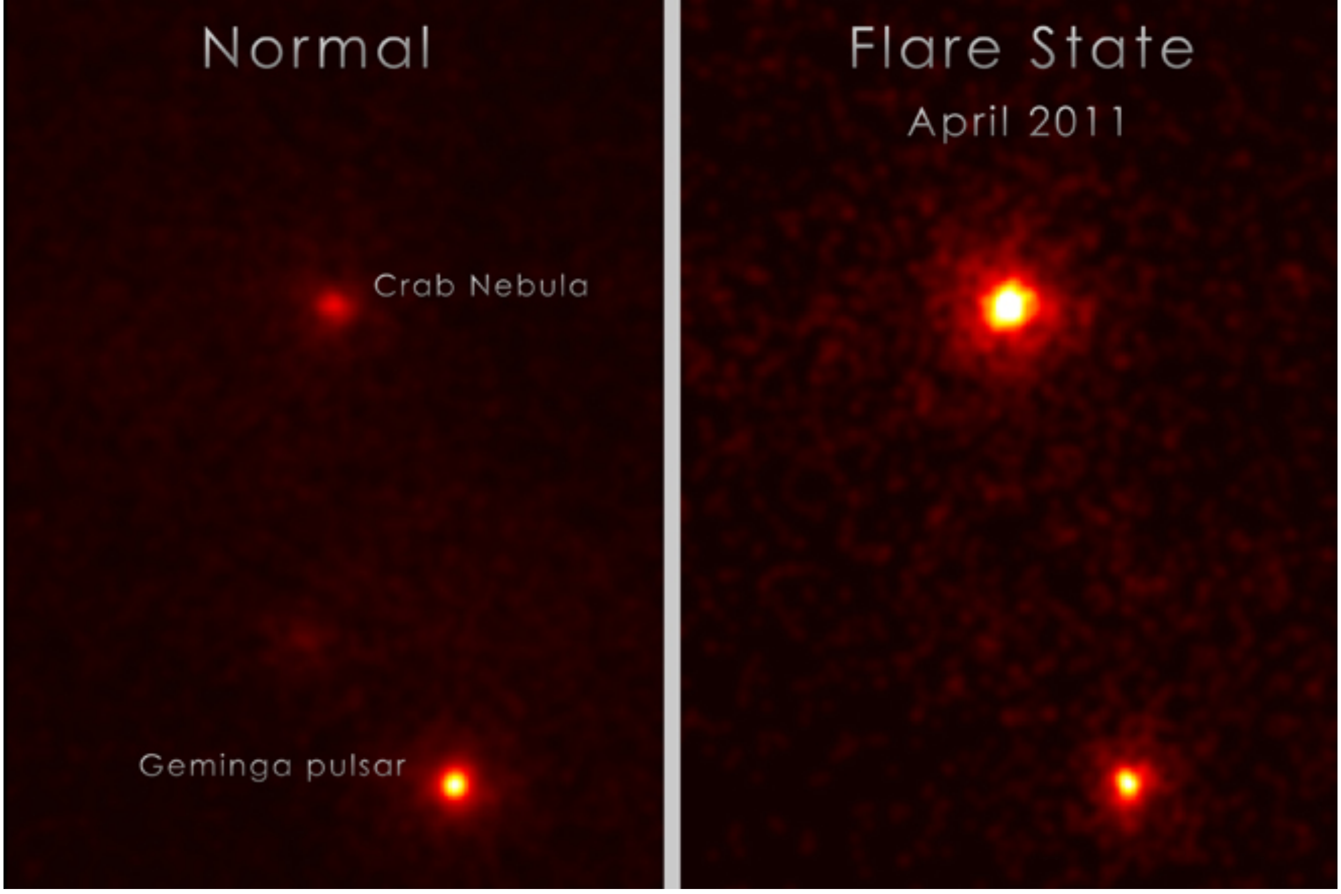
Earlier outbursts had already suggested that the Crab is producing gamma rays by accelerating electrons and positrons to energies around a quadrillion, or 10^{15}, electron-volts — about 100 times higher than the maximum energy of protons at the Large Hadron Collider, the world’s most powerful atom smasher. Because no signal can travel a distance greater than light can in a given period of time, the rapid variation of the April flares indicates that the charged particles were revved up within a tiny region of the vast Crab no bigger than the solar system, Buehler notes.

“The main question is how particles can be accelerated to such high energies so fast,” he says. The observations may require a new, separate population of energetic charged particles, similar to those that produce the strongest X-ray bursts associated with solar flares, says Jonathan Arons of the University of California, Berkeley.

Although the Crab’s gamma-ray flares are believed to be generated by electrons or positrons gyrating around magnetic fields, the energy of the observed radiation is several times higher than such a process can normally produce, says theoretical astrophysicist Mitchell Begelman.

In a theoretical model proposed by a University of Colorado team of Begelman, Uzdensky and Benoît Cerutti, the charged particles are accelerated near the nebula’s center where magnetic fields are violently rearranged, unleashing enormous amounts of energy in the presence of a strong electric field. Charged particles get sucked into the region, and the field enables them to form a higher-energy beam — and generate higher-energy radiation — than they normally would. The researchers posted their work online at arXiv.org on May 5. Although the study is based only on the older flares, the overall picture remains the same for the April outbursts, Uzdensky says.

Regions where magnetic fields are violently rearranged generate turbulence and undulations, which may result in wiggles in the beam of energetic charged particles and the gamma rays it produces. The fluctuations may occur simply because a wiggling beam could be seen only during the short time it swept across Earth’s line of sight.



Video: NASA's Gamma-ray Space Telescope recorded on April 12 the most powerful of a series of flares from the Crab nebula supernova remnant. As a NASA video explains, the origin of the energetic flares remains a mystery. (NASA)

Image: The Crab Nebula flaring up. Left: The region 20 days before the flare. Right: April 14, 2011. (NASA/DOE/Fermi LAT/R. Buehler)

See Also:

- Mysterious Cosmic Blast Keeps on Going
- Crab Nebula's Violent Outbursts Shock Astronomers
- Pulsing Stars Could Fill in for GPS Satellites
- Shields Up: Why Last Week's Solar Storm Was a Dud
- White-Light Solar Flares Finally Explained
- Ancient Supernova Triggered by Stellar Cannibal

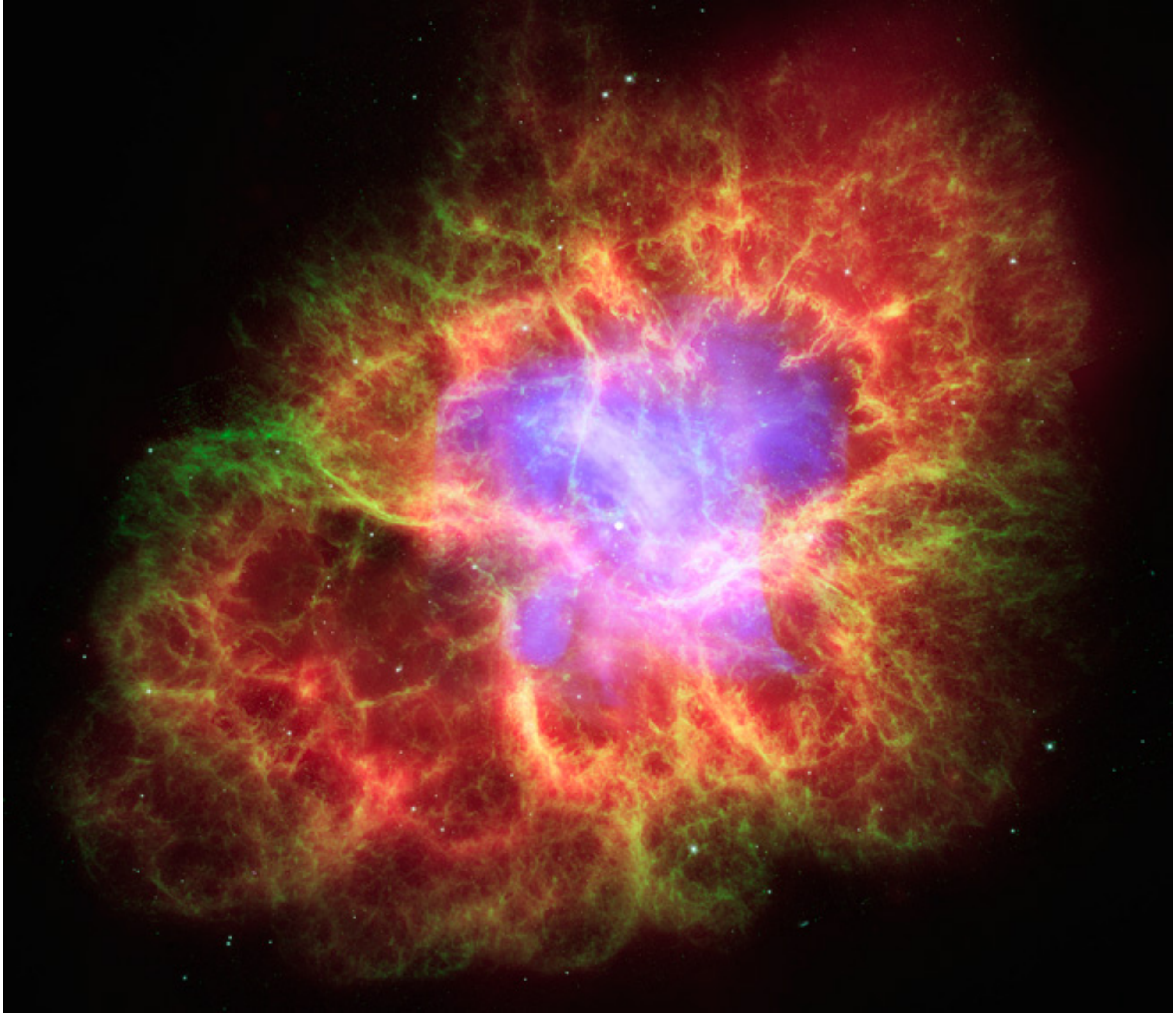
Tags: Space Crab Nebula Fermi telescope gamma rays ScienceNews.org supernova remnants

- #
-
- React

December 8 2010

18:55

Crab Nebula's Violent Outbursts Shock Astronomers



HEIDELBERG, Germany — Astronomers consider the Crab nebula one of the steadiest sources of high-energy radiation in the universe. Radiation from the supernova remnant is believed to be so constant that astronomers use it as a standard candle with which to measure the energetic radiation of other astronomical sources.

That's why researchers are astounded that two spacecraft recently recorded giant gamma-ray hiccups from the Crab, the remnants of a stellar explosion 6,500 light-years from Earth that was observed by humans in 1054. The intensity of the Crab's gamma-ray radiation suddenly became two to three times stronger for three days beginning September 19, scientists with the Italian Space Agency's AGILE telescope reported in a September 22 Astronomical Telegram, an e-mail communication. Researchers with Fermi's Gamma-ray Space Telescope found an even larger increase over roughly the same time period, they reported in a telegram on the following day. Both teams also announced they had found evidence of previous flares — the AGILE telescope recorded an outburst in the fall of 2007 while the Fermi team spotted one in February 2009.

The suspected source of the energetic flares, along with steadier radiation emanating from the nebula, is blizzards of electrons spat out by the Crab's pulsar — the rapidly rotating, exploded cinder of a star that lies at the very center of the Crab nebula. But figuring out exactly how the electrons got revved up to energies of at least 10^{15} electron volts — the most energetic charged particles ever associated with a distinct astrophysical object — for so short a time has astronomers at the biannual Texas Symposium on Relativistic Astrophysics, held this year in Heidelberg, Germany, scratching their heads and searching for new models.

Finding the flares "was a shock," said AGILE team member Marco Tavani of the INAF-IASF in Rome and the University of Rome Tor Vergata, who spoke about the findings at the meeting on December 6 and 7. In fact, when his team first noticed a sudden, short-lived rise in gamma-ray emissions from the Crab in the fall of 2007, soon after AGILE was launched, the researchers didn't believe it. Only when the craft recorded the 2010 outburst was the team convinced enough to go public with both findings. "If you say a steady source like the Crab is variable and it's not true, you burn yourself for life," Tavani said at the meeting.

In a paper posted online at www.arXiv.org on November 17 (http://arxiv.org/abs/1011.3855), the Fermi team noted that the findings "pose special challenges to particle acceleration theory."

Fermi researcher Rolf Buehler of the SLAC National Accelerator Laboratory in Menlo Park, Calif., joined Tavani in a hastily convened session on December 6, not part of the scheduled program, to discuss variable sources of energetic radiation in the Milky Way. Tavani and Buehler declined to talk to reporters because both of their teams have submitted their findings to *Science*.

In a widely accepted model, the stage is set for any kind of gamma-ray emissions — steady or short-lived — when electrons hurled from the Crab's central pulsar encounter strong magnetic fields in the surrounding debris. The electrons gyrate around the magnetic fields and get revved up to energies high enough to emit gammas.

But the Crab's recently detected outbursts would seem to pose problems for that acceleration model. The brevity of the flares indicates that the electrons couldn't have gyrated long enough to produce the energetic radiation, Buehler noted. Another problem: Because electrons accelerated to very high energies lose that energy quickly, the nebula's magnetic field might have to be three to 10 times stronger — 3 to 10 milliGauss — than is commonly assumed. (By comparison, Earth's surface magnetic field is about 500 milliGauss.)

The short duration suggests the gamma rays originate in a relatively small part of the inner nebula. Buehler suggested that the pulsar's own electric field helped accelerate the electrons in the inner part of the nebula to energies high enough to emit the gammas.

Wlodek Bednarek and a colleague from the University of Lodz in Poland offered another explanation. In a paper posted at www.arXiv.org on November 19 (http://arxiv.org/abs/1011.4176), they suggest that the pulsar's wind of charged particles rams into and compresses the magnetic field in the nebula. As the disrupted field snaps like a rubber band and reconfigures itself, it unleashes an enormous amount of energy that accelerates the electrons, the researchers propose.

As researchers puzzle over the details, astronomers are also trying to pinpoint the exact region from which the September outburst originated. As revealed in visible light and X- ray images, the nebula contains a complex array of wisps and jets. A series of portraits taken by the Chandra X-ray Observatory beginning a few weeks after the September flare shows that the base of one of the jets has brightened. This might be where the gamma-ray flare originated, says Tavani.

Figuring out the riddle presented by the Crab nebula is likely to shed new light on the nature of its pulsar, noted Jonathan Arons of the University of California, Berkeley. "All these particles come screaming out [of the pulsar] and get stopped in the nebula," which acts like the pulsar's catch basin, Arons said. "Studying what's going on in the inner nebula is as close as we can get to a laboratory experiment" to probe the pulsar, he added.

It may also help elucidate the physics of a host of other astronomical systems that feature a central compact object, Arons said. These include black holes whose jets of charged particles slam into surrounding interstellar space or collisions between clumps of material within such jets that are thought to create the most energetic explosions in the universe, events called gamma-ray bursts.

Image: A composite photograph of the Crab Nebula showing x-ray light (light blue), visible light (green and dark blue) and infrared light (red). Credit: NASA, ESA, CXC, JPL-Caltech, J. Hester and A. Loll (Arizona State Univ.), R. Gehrz (Univ. Minn.), and STScI

See Also:

- X-Ray Telescope's First 10 Years of Awesome Images
- Video: New 3-D Fly-Through of Supernova Remnant
- Pulsing Stars Could Fill in for GPS Satellites
- Top 10 Deep-Space Photos From Infrared Telescope's Final Days
- Baby Neutron Star Found Inside Supernova Remnant
- Twinkle, Twinkle, Little Blazar: Time-Lapse Video of Gamma-Ray Sky

Tags: Astronomy Physics Space astrophysics Crab Nebula Fermi telescope gamma rays nebula supernova remnants