Researchers suggest high energy emissions from Crab Nebula come from wind

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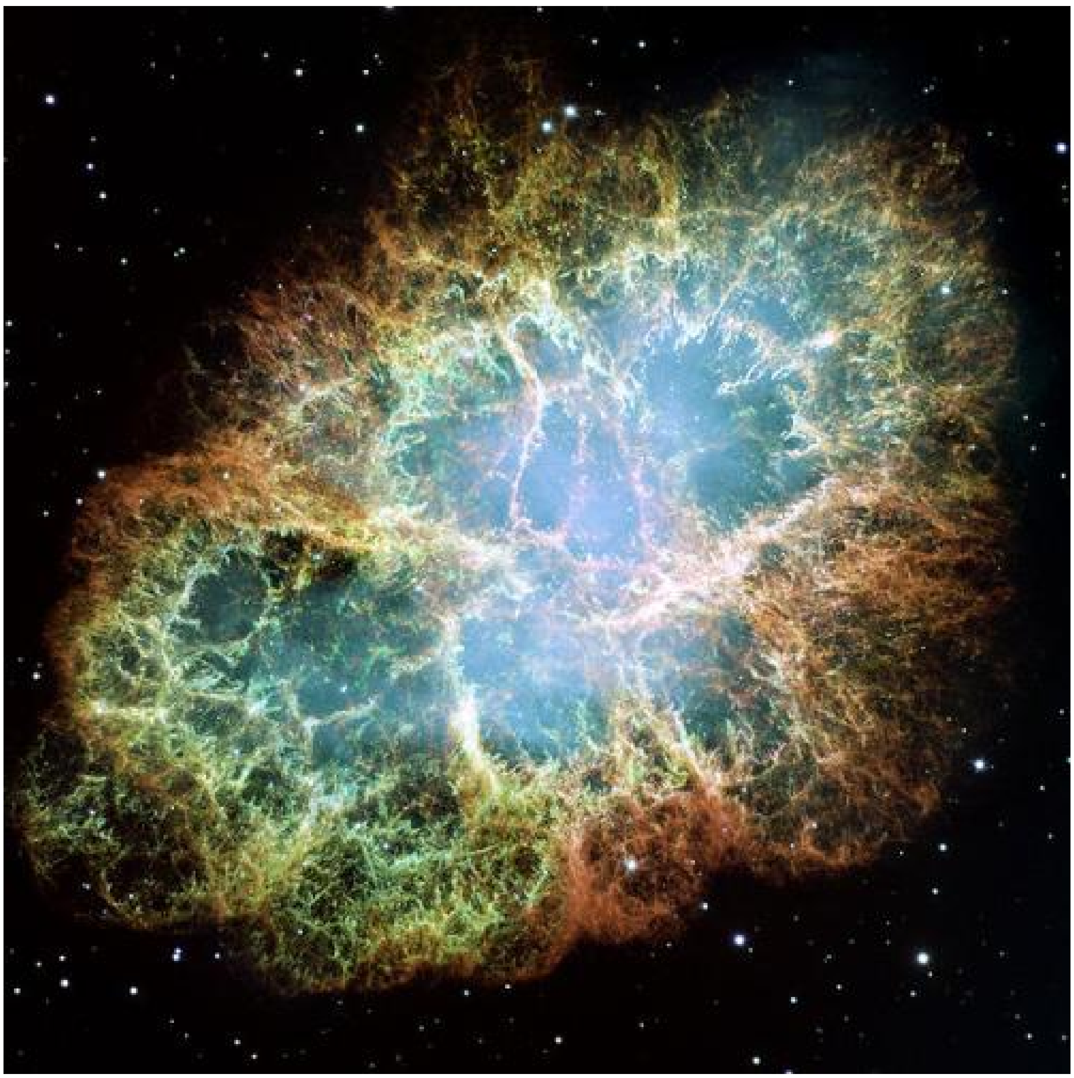

This is a mosaic image, one of the largest ever taken by NASA's Hubble Space Telescope of the Crab Nebula, a six-light-year-wide expanding remnant of a star's supernova explosion. Image: NASA

(PhysOrg.com) -- An international team of physicists studying the Crab Nebula have offered a new theory to explain its extraordinarily high energy emissions that have intrigued space scientists for years. The team, led by Felix Aharonian of the Dublin Institute for Advanced Studies, suggests that instead of the energy being emitted by the pulsar that sits at the center of the nebula, it comes instead from wind, as they describe in their paper in *Nature*, generated by the pulsar.

The Crab Nebula, of special interest to scientists for years, is what remains after a supernova exploded close to a thousand years ago, and the pulsar is what was left over; a very dense neutron star that spins at thirty times per second. Because the pulsar appears to pulse, hence it's name, scientists have assumed that the high energy emissions from the nebula came directly from it, especially since the energy comes in bursts that come at the same rate as the pulses. But recent research has shown that what appears to be a pulse from the pulsar is actually more than that. The pulsar actually generates a continues beam of radiation that appears to pulse only when that beam heads our way.

In this new research Aharonian and his team traced back the energy emissions from the nebula and found that it didn't lead straight to the pulsar, but to a point somewhat near to it. To explain this, they've come up with a theory that suggests that the energy from the pulsar moves away from the pulsar into the rest of the nebula, where it is captured by a wind that carries it out into space. Though this wind cannot be seen, its presence can be theorized based on the behavior of nebula.

In studying the behavior of the wind, the team has found that in its initial stages, it appears to be dominated by electromagnetic energy, but then becomes much more kinetic at some point by some process that is still not understood. They also believe they can estimate where it originates by noting that if it were too close to the pulsar, they gamma ray emissions would have to be higher. Conversely, if it were any farther than a certain point, the photons it carries would be too dim to be seen. Aharonian's group next plans to focus on explaining why the wind picks up speed as it moves out of the nebula.

More information: Abrupt acceleration of a 'cold' ultrarelativistic wind from the Crab pulsar, *Nature* (2012) doi:10.1038/nature10793

Abstract
Pulsars are thought to eject electron–positron winds that energize the surrounding environment, with the formation of a pulsar wind nebula. The pulsar wind originates close to the light cylinder, the surface at which the pulsar co-rotation velocity equals the speed of light, and carries away much of the rotational energy lost by the pulsar. Initially the wind is dominated by electromagnetic energy (Poynting flux) but later this is converted to the kinetic energy of bulk motion. It is unclear exactly where this takes place and to what speed the wind is accelerated. Although some preferred models imply a gradual acceleration over the entire distance from the magnetosphere to the point at which the wind terminates, a rapid acceleration close to the light cylinder cannot be excluded. Here we report that the recent observations of pulsed, very high-energy γ-ray emission from the Crab pulsar are explained by the presence of a cold (in the sense of the low energy of the electrons in the frame of the moving plasma) ultrarelativistic wind dominated by kinetic energy. The conversion of the Poynting flux to kinetic energy should take place abruptly in the narrow cylindrical zone of radius between 20 and 50 light-cylinder radii centred on the axis of rotation of the pulsar, and should accelerate the wind to a Lorentz factor of $(0.5–1.0) \times 10^6$. Although the ultrarelativistic nature of the wind does support the general model of pulsars, the requirement of the very high acceleration of the wind in a narrow zone not far from the light cylinder challenges current models.