Hubble telescope reveals dancing Crab

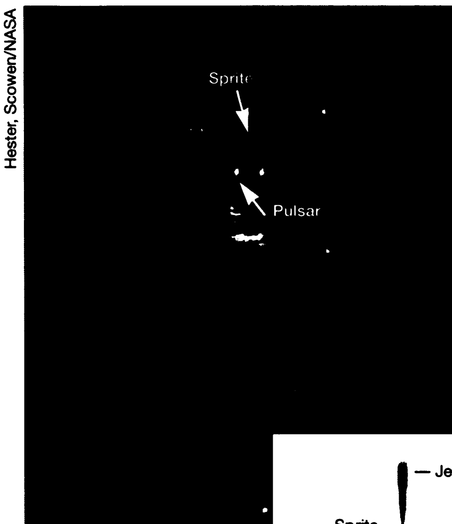
A whirling dervish lies at the heart of the Crab nebula, the giant remnant of a blazing stellar explosion that Chinese astronomers witnessed 942 years ago. Though less than a ten thousandth the size of Earth, the rapidly rotating powerhouse—the shrunken core of the exploded star—lights up the entire nebula, which is big enough to hold more than 600 solar systems.

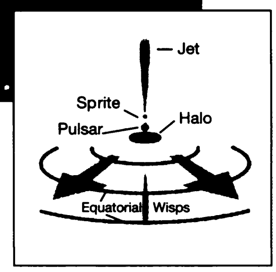
Astronomers discovered nearly 3 decades ago that the compact engine powering the Crab is a pulsar, so named because the body's twin searchlights sweep across Earth 30 times a second. Yet even though the Crab ranks as one of the most thoroughly studied objects in the sky, ground-based observers have never fully documented how the pulsar imparts its energy to the nebula.

Now, a movie made from a series of Hubble Space Telescope images reveals that the region around the pulsar changes dramatically in just a few days, much faster than Earth-based observations had indicated. The movie shows that just above the pulsar lies a flickering blob of light, nicknamed a "dancing sprite" because of its capricious variation in brightness and position. The film also shows equatorial wisps, concentric waves of light generated by charged particles flung from the pulsar's equator at nearly the speed of light.

"In astronomy, normally if you can see something change over the course of your career, you're excited," says J. Jeffrey Hester of Arizona State University in Tempe. Using Hubble, he and his colleagues "found that the Crab is so dynamic that if you wait more than about a week to take your next look, you're going to get the wrong impression because things have changed so terribly much." Hester and his Arizona State colleague Paul A. Scowen presented the findings last week at a NASA press briefing in Washington, D.C.

Hester, Scowen/NASA





Hubble image of the inner part of the Crab nebula shows its pulsar, as well as a flickering feature described as a sprite. Inset: Schematic of the environment around the pulsar, showing twin jets emanating from its poles and material flung out along its equator.

The images, Hester says, demonstrate that the pulsar doesn't spew its energy in all directions. Rather, much of the energy shows up around the equator, emanating from a wind of electrons and positrons generated by the pulsar's intense magnetic field. The spiraling particles radiate light, illuminating the Crab's interior and traveling far into the nebula. Similarly, high-speed jets of electrons and positrons travel out from the pulsar's polar regions. The sprite, Hester points out, marks the region where material from one of these jets blasts into slower-moving material in the nebula.

"We've thrown down the gauntlet," declares Hester. "Any model of a pulsar and its wind is going to have to come to grips with what we see going on in the Crab."

Although Andrew S. Fruchter of the Space Telescope Science Institute in Baltimore cautions that the analysis of the images "is not set in stone," he says the pictures offer "the best close-up view of a pulsar wind that we've ever had."

The processes unveiled in the Crab may be a scaled-down version of those at work in the centers of active galaxies that lie too far away to be studied at high resolution. "The Crab allows the properties and behavior of high-energy winds to be studied up close and personal," says Hester. —*R. Cowen*

Climate modelers: Go talk to the trees

Though the last ice age ended 10,000 years ago, it continues to chill the spirits of climate scientists around the world.

In trying to understand how climate works, researchers use advanced computer models to simulate conditions during different periods of Earth's history. Yet even the best of these models have failed to reproduce the chilly temperatures that permitted vast glacial sheets to spread over parts of North America, Europe, and Asia during the last ice age.

The solution to this cold conundrum lies in the boreal forests of northern lands, according to new computer simulations described in the June 6 NATURE. Though ignored in previous modeling studies, vegetation actually plays a significant role in climate—one large enough to send the world spiraling into an ice age, report Robert G. Gallimore and John E. Kutzbach of the University of Wisconsin-Madison.

"This has been a significant problem that has puzzled people, and I think they have offered a reasonable explanation," comments Thomas J. Crowley of Texas A&M University in College Station.

In the new computer simulations, plants perform a reinforcing role, exaggerating an initial cooling caused by cyclical changes in Earth's orbit. At the start of the last ice age, 115,000 years ago, several factors cooled the Northern Hemisphere during summer. Earth traveled in a more elliptical orbit then and reached its farthest point from the sun in July. The planet's spin axis also tilted less than it does today, reducing the difference between seasons.

These changes caused an 8 percent reduction in the amount of summer radiation reaching far northern lands. Moreover, Earth's atmosphere held 20 percent less carbon dioxide, which cooled climate even further. These two effects represent only part of the answer, however, because in model simulations, they do not depress temperatures enough to create an ice age.

When Gallimore and Kutzbach included changes in plant communities, northern summers grew so cold that snow persisted year round north of 60°N latitude. Enough snow accumulated each year that kilometer-thick ice sheets could grow in 6,000 years, according to the simulation.

To mimic vegetation's influence on climate, the two researchers drew on the results of a previous study that examined ecological effects of orbital changes 115,000 years ago. This work suggested that as Earth's temperature dropped, about 25 percent of the land covered by boreal forests gave way to tundra.

This simple plant shift produced a profound cooling effect in the climate model. Snow-covered tundra reflects 50 to 70 percent of incoming sunlight back to space. In contrast, the dark branches of evergreen trees absorb solar radiation, so a boreal forest in winter reflects only 15 to 20 percent of sunlight. With the addition of tundra, summertime temperatures dropped by 8°C to 15°C at latitudes between 60°N and the pole, the researchers found.

These simulations, as well as other recent studies, demonstrate that vegetation changes can influence climate strongly, says Mark Chandler of NASA's Goddard Institute for Space Studies in New York. For that reason, modelers are now striving to marry ecological models to sophisticated global climate models—a union designed to let plants interact more realistically with climate and to improve forecasts of global change. —*R. Monastersky*