Craft Finds New Evidence of Magnetars

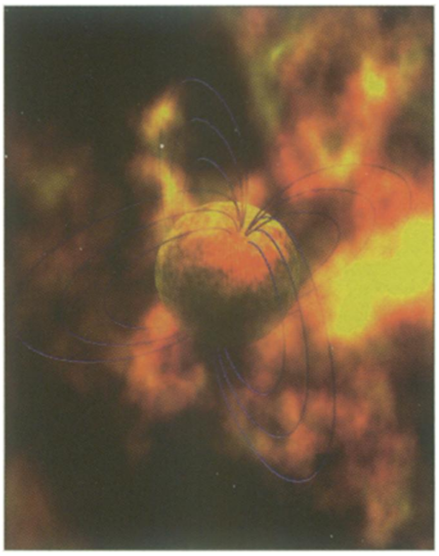
Late last month, astronomers witnessed a star going berserk. Ever since they saw it hiccuping X rays during the last week of May, researchers had been taking daily observations of this Milky Way resident. On Aug. 27, the star sent a spectacular flood of gamma rays coursing through the solar system.

The initial pulse jolted detectors on at least six spacecraft, driving several of the instruments off-scale. Like a fading echo, a lower-energy tail of radiation followed, lasting for 5 minutes and setting what appears to be a new record. Never before has a stream of gamma rays dumped so much energy in Earth's vicinity.

But it's not the sheer amount of energy from the star, known as SGR 1900+14 for its sky coordinates, that has jazzed astronomers. It's the prospect that this star, only about 26,000 light-years from Earth, may offer the best evidence yet for the existence of magnetars, new and bizarre members of the celestial zoo. Such objects, first envisioned by theorists in 1992, would possess the strongest magnetic fields known in the universe.

These magnetic fields would range in strength from 100 trillion to 1 quadrillion gauss. That's 100 to 1,000 times stronger than the fields that typically exist on ultradense stars known as neutron stars. Magnetars in fact would be a special class of neutron stars, their magnetic fields producing such strange and dramatic effects as quakes and fractures.

Strange beasts in their own right, neutron stars pack more mass than the sun's into a sphere with a cross-section the size of a small city. Their intense gravity squeezes protons and electrons into a fluidlike core of neutrons, encased by a solid crust. In a neutron star that's spinning fast enough, swirling motions within the core could wind up and amplify the magnetic field to enormous strength, creating a magnetar.



R. Mallozzi/Univ. of Alabama in Huntsville and NASA

Artist's depiction of a magnetar. Lines radiating from top indicate the magnetic field.

The enormous magnetic field would generate unbearable stresses, cracking the magnetar's crust, notes theorist Robert C. Duncan of the University of Texas at Austin. As it rips the crust, the field would unleash a torrent of energy that could trigger quakes and set the crust vibrating. As Duncan describes it, the heaving star drives magnetic waves outward, energizing clouds of charged particles just above the surface. These charged particles would radiate gamma rays—just like the streams of radiation produced by SGR 1900+14, assert Duncan and his colleague Christopher Thompson of the University of North Carolina at Chapel Hill.

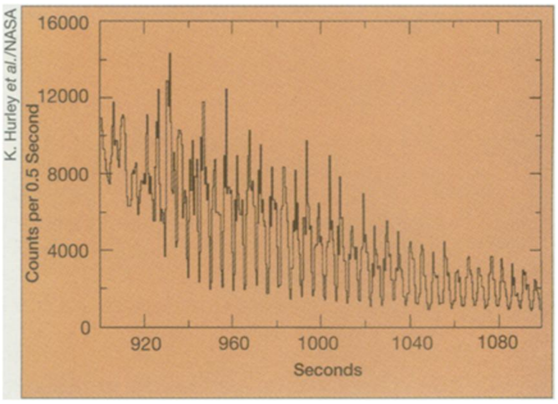
More rarely, sections of the magnetic field that thread through the magnetar would undergo an abrupt rearrangement, snapping like a rubber band and then reconnecting. On the sun, a milder version of this process generates bursts of radiation known as solar flares. The much stronger field of a magnetar could produce a spike of gamma rays like the one that began the Aug. 27 event, Duncan says.

A brief, intense spurt of gamma rays emitted 19 years ago by another star, SGR 0526-66, may also indicate the presence of a magnetar. SGR 1900+14 and SGR 0526-66 belong to a class of stars known as soft gamma-ray repeaters because they sporadically emit low-energy gamma rays.

Three months before the August outburst, astronomers found another reason to suspect that SGR 1900+14 has a huge magnetic field.

Neutron stars, which are produced when massive stars suffer a catastrophic explosion, tend to spin rapidly in their youth. Although SGR 1900+14 is thought to be young, it spins slowly, at about 5 revolutions per second. Moreover, observations of the star's steady output of X rays with the ASCA satellite in April and the Rossi X-ray Timing Explorer in June revealed that the spin speed was rapidly dropping at a rate of 60 trillionths of a second every second. A strong magnetic field can explain a slow and diminishing spin: It acts as a brake, converting rotation into waves of energy that radiate into space.

The rotation and slowdown rate observed would require a magnetic field of 500 trillion gauss, and such a field strength "strongly suggest[s] that SGR 1900+14 is a magnetar," report Chryssa Kouveliotou of Universities Space Research Association at NASA's Marshall Space Flight Center in Huntsville, Ala., Kevin C. Hurley of the University of California, Berkeley, and their collaborators.



Data from the craft Ulysses show the spurt of gamma rays, emitted by the star SGR 1900+14, that swept through the solar system on Aug. 27. The radiation abruptly peaked and then diminished in intensity over 300 seconds. The intensity oscillates every 5 seconds, the star's rotation rate.

Their announcement, in an Aug. 28 circular of the International Astronomical Union, followed a report by several members of the same team in the May 21 NATURE. That study, of the star SGR 1806-20, contained the first data on rotation and slowdown that argued for a superstrong magnetic field.

The evidence that SGR 1900+14 is a magnetar appears to be even more compelling than the case for SGR 1806-20, says Duncan, because a different set of data from the Ulysses craft points to the same conclusion. Those data originate from the slowly declining tail of gamma-rays observed on Aug. 27. That decline, as well as the total amount of energy radiated, suggests that a strong magnetic field was in place, trapping blobs of hot, ionized gas in the star's vicinity while they gradually emitted gamma rays.

"The fact that we have both lines of evidence is fantastic," says Kouveliotou. Assuming that all five known repeaters, as well as a handful of related objects called anomalous X-ray pulsars, are magnetars, Duncan estimates that at least 10 percent and possibly half of all neutron stars belong to this class. He notes that after about 10,000 years, these objects should slow considerably, dissipate their magnetic energy, and cease to emit bright X rays. Our own galaxy, he says, may harbor 100 million slowly rotating dark stars that once carried extraordinarily potent magnetic fields. —*R. Cowen*