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UCSD astronomers' findings cast doubt on the existence of powerful magnetic fields

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UCSD ASTRONOMERS' FINDINGS CAST DOUBT ON THE EXISTENCE OF POWERFUL MAGNETIC FIELDS

New astronomical observations of extremely compact and dense neutron stars, sources of some of the most intense bursts of high-energy radiation in the Galaxy, call into question a popular theory about their fundamental composition.

The theory holds that these stars contain the universe's strongest magnetic fields, the sources of the strange and potent energy bursts. But a team of astrophysicists at the University of California, San Diego argues that the theory has significant flaws. Instead, they say, the strange energy bursts may be due to the strong wind of particles ejected by the peculiar stars, called "soft gamma-ray repeaters."

Soft gamma-ray repeaters occasionally emit brief bursts of gamma- and X-ray radiation that are more than a million times more powerful than the Sun. One such burst from a soft gamma-ray repeater on August 27, 1998 released so much energy that it disrupted radio transmissions on Earth and temporarily disabled some instruments aboard Earth-orbiting satellites.

The popular "magnetar theory" holds that the soft gamma-ray repeaters, examples of neutron stars, have magnetic fields that are more than a million times stronger than the most powerful magnets available in laboratories on Earth, and 10 to 100 times stronger than the observed magnetic fields of normal neutron stars.

The magnetic fields of soft gamma-ray repeaters are so strong, the theory holds, that the magnetic energy of the star can be released episodically producing the observed bursts of high energy radiation. But observations of one of the four known soft gamma-ray repeaters, and the source of the extremely energetic burst last August, casts doubt on the magnetar interpretation.

The study, which will appear in an upcoming edition of Astrophysical Journal Letters, uses a precise timing analysis of the X-ray signals from the soft gamma-ray repeater, called SGR 1900+14, to doubt the existence of the super strong magnetic fields predicted by the magnetar theory. David Marsden, Richard Rothschild, and Richard Lingenfelter of the Center for Astrophysics and Space Sciences at UCSD argue that the strange behavior seen from SGR 1900+14 may instead be due to the strong wind of particles ejected by the neutron star.

The observations, which used data from Rossi X-ray Timing Explorer satellite, precisely measured both the spin period and the rate at which SGR 1900+14 was slowing down. Using the X-ray data, the spin period was precisely measured to be 5.1558199 seconds, and the rate of change of the period was 2 milliseconds per year.

Solitary neutron stars such as soft gamma-ray repeaters gradually slow down by losing energy to the environment surrounding the star.

The process can be compared with friction in a bicycle wheel. After the wheel is initially set spinning, it will gradually slow down due to energy lost to friction between the wheel and the axle. If SGR 1900+14 has a superstrong magnetic field, a similar process should occur due to "friction" provided by radiation from the magnetic field. The theoretical calculations indicate that the age of the SGR 1900+14 should be less than one-half the spin period divided by the rate at which the star is slowing down.

Using this theory, the researchers calculated SGR 1900+14 to be less than 1,000 years old. The problem with the theory of the superstrong magnetic fields is that the age of SGR 1900+14 must be much older than this. This is because soft gamma-ray repeaters, and neutron stars in general, are formed when a star more massive than the Sun ends its life in a fiery explosion. These powerful explosions, called supernova, leave remnants that are visible throughout the Galaxy as expanding clouds of hot gas that gradually fade from view over a period of approximately 20,000 years.

From the size and brightness of supernova remnants, their ages can be estimated. The supernova remnant that gave birth to SGR 1900+14 is very faint, indicating that it is an old remnant, and it is estimated to be greater than 10,000 years old, which is at least 10 times older than the age of SGR 1900+14 inferred by assuming the spin down is due to the magnetic field. A similar discrepancy in ages is seen for SGR 1806-20, another of the soft gamma-ray repeaters also theorized with a superstrong magnetic field.

"The problem is akin to being older than one's mother, it's nonsensical," said Marsden, a paper co-author.

Instead, the researchers suggest a different explanation for the fast slowdown of SGR 1900+14, one that does not involve unusually strong magnetic fields. In their interpretation of the new data, a steady wind of high energy particles is being thrown away from the neutron star carrying away rotational energy and slowing down the star.

"The situation is analogous to an ice skater spinning with weights in each of her outstretched hands," explained Marsden. "If she throws the weights outward, she would slow down due to rotational energy carried away by the weights."

The UCSD group has calculated that such a wind can explain the observed spin period and rate of change of the period of SGR 1900+14 for a supernova remnant age of 15,000 years, which is consistent with the estimated age of the supernova remnant that produced the soft gamma-ray repeater. The researchers stress that there are still unresolved issues concerning the soft gamma-ray repeaters. In particular, the mechanism that powers the wind of high energy particles is unknown. One possible explanation for the wind is that it consists of magnetic waves that are excited by starquake vibrations of the neutron star surface.

As these magnetic waves move away from star, they accelerate wind particles due to their rapidly fluctuating magnetic and electric fields. But whatever the mechanism for the wind, the researchers stress that existence of a superstrong magnetic field is not supported by the data on SGR 1900+14.