Star exploding inside another star sheds light on super stellar explosions

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An international team of astronomers today is reporting on a discovery of a star exploding inside another star. The discovery is helping astronomers learn more about the structure of a red giant star, how shock waves move through a star and revealing how one type of binary star system goes through the end stages of its life, the astronomers report.

Speaking at the National Astronomy Meeting in Leicester, U.K., the international team of 14 astronomers described what they saw as they monitored the explosion of RS Ophiuchi, a recurrent nova that lights up in the sky roughly every 20 years. RS Oph, as it is called, normally a very dim object in the sky was found to be visible to the unaided eye on Feb. 12, 2006 by Japanese amateur astronomers.

It was the fifth time in the last 108 years RS Oph exploded, and the first time it was viewed in unprecedented detail by an armada of space- and ground-based telescopes, said Sumner Starrfield, an ASU Regents professor of astronomy and a member of the international team monitoring the star system. Starrfield leads the U.S. portion of the effort. Among the telescopes and detectors trained on RS Oph were x-ray telescopes, an infrared telescope and a radio telescope.

While RS Oph is a well-known and well-documented star system the fact that the astronomers were able to train their instruments and telescopes on the object early in the explosion process is shedding new light on it, Starrfield said.

"We were floored to see how bright this star was in x rays when we first observed it, and then it changed every day we pointed at it with our telescopes," Starrfield said. "We estimate the gas exploded off the white dwarf to be about 100 million degrees, about six times hotter than the gas at the center of our Sun. We are seeing about an Earth mass of material expand at more than 10 million kilometers/hour. The expanding gas from the explosion is now larger in size than our own solar system."

RS Oph is more than 5,000 light years away from Earth in the constellation Ophiuchi. A binary star system, it consists of a white dwarf star (the super-dense core of a star, about the size of the Earth, that has reached the end of its main hydrogen-burning phase of evolution and has shed its outer layers) in close orbit with a much larger red giant star (which is one step behind it in terms of its life-cycle).

The two stars are so close together that hydrogen-rich gas from the outer layers of the red giant is continuously pulled onto the dwarf by its high gravity. After about 20 years of this, enough gas has been accreted that a runaway thermonuclear explosion occurs on the white dwarf's surface. The luminous energy increases in less than a day to more than 100,000 times that of the Sun, and the accreted gas (several times the mass of the Earth) is ejected into space.

"This explosion is similar to that of a terrestrial hydrogen bomb," says Starrfield. "RS Oph can be thought of as one of the largest and most powerful hydrogen bombs in the universe."

To get explosions like this five times a century means that the white dwarf must be near a maximum mass without collapsing to become an even denser neutron star or black hole. What is also unusual in RS Oph is that because the red giant is losing enormous amounts of gas in a wind that envelops the whole system, the explosion on the white dwarf occurs 'inside' its companion's extended atmosphere and the very high speed

ejected gas then slams into it.

"We are learning about the chemical composition of the red giant and how fast it is losing matter itself," Starrfield explained. "With this information we can predict how much longer the red giant will live before becoming a white dwarf."

If the red giant lives long enough, then the white dwarf could explode as a white dwarf supernova, which is the "type of supernova that astronomers use to study the evolution and fate of the universe itself," Starrfield said. "Studies of RS Oph can shed light on these tremendous explosions that can be seen across the universe."

O'Brien, of Jodrell Bank Observatory, said that by looking at this explosion with advanced technology telescopes, the astronomers are recording in unprecedented detail the entire explosion process.

"Both radio and x-ray observations from the last outburst gave us tantalizing glimpses of what was happening as the outburst evolved," O'Brien said. "This time we have developed much more advanced computer models and more sensitive telescopes. We have also opened the x-ray part of the spectrum to highly detailed studies. The combination of the two (instruments and models) will undoubtedly lead to a greater understanding of the circumstances and consequences of the explosion."

Michael Bode, leader of the UK team and the person who presented at the National Astronomy Meeting, added that RS Oph is a rare combination of a known star system with a predictable pattern of exploding every 20 years.

"We have a unique opportunity [through the study of RS Oph] to better understand such things as run away thermonuclear explosions and the

end points of the evolution of stars," Bode said.

In addition to Starrfield, the team monitoring RS Oph includes Michael Bode of Liverpool John Moores University, U.K.; Tim O'Brien, Jodrell Bank Observatory, University of Manchester, U.K.; Julian Osborne and Kim Page, University of Leicester, U.K.; Stewart Eyres, University of Central Lancaster, U.K.; and Nye Evans, University of Keele, U.K.

Source: Arizona State University