Mystery of explosive star solved

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A artist's impression of the nova explosion in RS Ophiuchi.

In February, a faint star a few thousand light-years away flared suddenly, beaming so brightly that for a few days it was visible to the naked eye.
The star is a stellar corpse the size of Earth, known as a white dwarf, and it is paired in a binary system with a red giant, a dying, bloated star that once resembled our sun. The red giant has been dumping gas onto the surface of the white dwarf, and every few years, enough matter accumulates to set off a giant thermonuclear explosion.

It was one of these explosions, called a "nova," that astronomers and stargazers detected earlier this year.

The two-star system, called RS Ophiuchi, is known as a recurrent nova because five similar eruptions have been detected before. The first observation occurred in 1898; the last eruption prior to this latest one happened in 1985.
The new observations, made using advanced radio and X-ray telescopes not available during the last outburst, reveal the explosion to be more complex than was previously assumed.

Standard computer models had predicted a spherical explosion with matter ejected in all directions equally. The latest observations instead showed that the explosion evolved into two lobes, confirming suspicions that the nova outburst produces twin jets of stellar material that spews out from the white dwarf in opposite directions.
"The radio images represent the first time we've ever seen the birth of a jet in a white dwarf system. We literally see the jet 'turn on,'" said Michael Rupen, an astronomer at the National Radio Astronomy Observatory who studied RS Ophiuchi using the Very Long Baseline Array (VLBA).

As impressive as the nova are, they might just be precursors for a more violent supernova explosion that will occur in the future, scientists say.

The white dwarf's thermonuclear blasts are similar to those that occur on the surface of the sun, but they can be over 100,000 times more powerful. During each outburst, an amount of gas equal to the mass of the Earth is flung into space.

Some of this ejected matter slams into the extended atmosphere of the inflated red giant, creating blast waves that accelerate electrons to nearly the speed of light. As the electrons travel through the stars' magnetic fields, they emit radio waves that can be detected by telescopes on Earth.

The blast waves move at over four million miles (about 6.4 million kilometers) per hour. For a few weeks during each outburst, the white dwarf becomes a red giant.

"After the [thermonuclear explosion], the white dwarf will puff up into a red giant for a few weeks as the hydrogen that has been blasted into space fuses into helium," explains Richard Barry of the NASA Goddard Space Flight Center in Maryland.

All eyes on Ophiuchi

Japanese astronomers first detected signs of RS Ophiuchi's latest nova on the night of February 12. Follow-up observations by radio telescopes revealed an expanding blast wave whose diameter was already the size of Saturn's orbit around the Sun.

In the weeks following, several radio and X-ray telescopes around the world tracked RS Ophiuchi closely, including the MERLIN array in the UK, the European EVN array, the Very Long Baseline Array (VLBA) and Very Large Array

(VLA) in the United States, and NASA's Swift and Rossi X-ray Timing Explorer satellites.

Findings from the Rossi X-ray Timing Explorer and the VLBA/EVN observations are detailed in two separate studies published in the July 20 issue of the journal Nature.

The red giant and white dwarf stars making up RS Ophiuchi are separated by about 1.5 astronomical units, or one and a half times the distance the Earth is from the sun. The binary star system is located in the constellation Ophiuchus, about 5,000 light-years away -- very close by astronomical standards.

"We have a ringside seat for this very important event," Barry told SPACE.com. Barry is a co-author on another study on RS Ophiuchi that will appear in an upcoming edition of Astrophysical Journal.

Supernova precursor?

When the outburst is over, gas will once again build up on the white dwarf and the explosions will begin anew, perhaps in some 20 years time. It's unknown whether the white dwarf casts off all of its accumulated matter during each eruption, or whether some of the material is being hoarded and slowly increasing the mass of the dead star.

"If the white dwarf is increasing in mass then it will eventually be ripped apart in a titanic supernova explosion and the cycle of outbursts will come to an end," said Tim O'Brien of the University of Manchester, a co-author on one of the Nature studies.

White dwarfs must attain a critical 1.4 solar masses before they can explode in what scientists call a Type 1a supernova. The white dwarf in RS Ophiuchi is near this critical limit now, but it will still probably need hundreds of thousands of years to accumulate the final bit of mass, scientists say.

Because all Type 1a supernovas emit the same amount of light at their peak, they serve as important "standard candles" which astronomers use to calculate cosmic distances.

"Our understanding of these objects is exceedingly important as any miscalculation or uncertainty in the total light of output of supernovae could have a dramatic effect on our calculations of the scale and size of the entire universe," Barry said.