Nuclear explosion on a dead star -- astronomers probe aftermath

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A team of astronomers from the UK and Germany have found that a nuclear explosion on the surface of a star 5,000 light years from Earth resulted in a blast wave moving at over 1,700 km per second (one thousand miles per second or almost four million miles per hour!). The discovery, reported in the 20th July issue of *Nature*, was made by bringing together many of the world's radio telescopes into arrays capable of seeing the aftermath of the explosion in incredible detail.

During the night of 12th February this year Japanese astronomers reported that a star called RS Ophiuchi had suddenly brightened and become clearly visible in the night sky. Although this was the latest in a series of such outbursts that have been spotted over the last hundred years or so, it was the first since 1985 and therefore an opportunity to bring to bear new, more powerful, telescopes in an effort to understand the causes and consequences of these eruptions.

Dr Tim O'Brien of The University of Manchester's Jodrell Bank Observatory requested urgent observations with the VLBA (the Very Long Baseline Array of radio telescopes extending from Hawaii to the Caribbean). "Our first observations, made only two weeks after the explosion was reported, showed an expanding blast wave already comparable in size to Saturn's orbit around the Sun. However, we needed to use the world's most powerful radio telescopes because, from a distance of 5,000 light years, its apparent size on the sky was only 5 millionths of a degree – the size of a football seen from 2,700 km (1,700 miles) away."

He goes on to explain "The blast wave results from a huge nuclear explosion which takes place on the surface of one of a pair of stars, about 5,000 light years from Earth, which are closely circling one another. Gas captured from one star, a red giant, builds up on the surface of its white dwarf companion (a super-dense dead star about the size of the Earth which was once the core of a star like the Sun whose outer layers have been lost into space)."

Professor Mike Bode of Liverpool John Moores University describes what happens next. "Eventually enough gas collects on the white dwarf for thermonuclear reactions to begin, similar to those which power the Sun but which runaway into a massive explosion. In less than a day, its energy output increases to over 100,000 times that of the Sun, and the gas (about the mass of the Earth) is thrown into space at speeds of several thousand km per second. This ejected matter then slams into the extended atmosphere of the bloated red giant and sets up blast waves that accelerate electrons to almost the speed of light. The electrons release radio waves as they move through a magnetic field, that are then picked up by the telescope arrays."

Over the following months, the team continued to track the outburst using the MERLIN array of radio telescopes in the UK, the Very Long Baseline Array (VLBA) and Very Large Array (VLA) in the USA and the European VLBI Network (EVN) which includes telescopes in South Africa and China, a truly global effort. At the same time, they were working with other astronomers across the world using NASA's Swift satellite to detect X-rays from gas heated to up to 100 million degrees Celsius (nearly 10 times that in the core of the Sun) by the expanding blast wave. The results from the first month of these X-ray observations are described in a separate paper accepted for publication in The Astrophysical Journal.

Dr Richard Porcas of the Max Planck Institute for Radio Astronomy in

Bonn coordinated the European VLBI Network observations. “A week after our first observations, we combined telescopes across Europe with two in China and another in South Africa and were surprised to find that the blast wave had become distorted. Over the next few months our observations have shown it turning from a ring into a cigar-like shape. It’s going to need a lot more work to understand exactly what causes this but either the explosion shoots jets of matter in opposite directions or somehow the atmosphere of the red giant is shaping the ejected material.”

Dr Stewart Eyres of the University of Central Lancashire has been monitoring the brightness of the radio source with MERLIN and the VLA. “During this outburst, our first observations with the UK’s MERLIN system were made only four days after the outburst and showed the radio emission to be much brighter than expected. The later behaviour suggests a complex mix of emission from relativistic particles and hot gas in the expanding remnant of the explosion.”

Once the outburst is over, gas will again build up on the white dwarf until at some point, maybe another 20 years in the future, RS Oph should explode again. An important question which the astronomers hope to answer is whether in each explosion the white dwarf throws off all the matter it has collected from the red giant or whether it is hoarding some material and therefore gradually increasing in mass.

Dr Tim O’Brien, who also studied RS Oph’s previous outburst in 1985 for his doctoral thesis, concludes “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.”

Source: PPARC