Hubble space telescope reveals the aftermath of 'Star Wars'

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An Anglo-American team of astronomers have used the Advanced Camera for Surveys on the Hubble Space Telescope (HST) to obtain the first direct optical images of the aftermath of a recent titanic explosion that took place in a star system 5,000 light years from Earth.

In a talk on Tuesday 17 April at the Royal Astronomical Society National Astronomy Meeting in Preston, Professor Michael Bode of Liverpool John Moores University described how these unique observations shed new light on the circumstances of such events.

During the night of 12 February 2006, Japanese amateur astronomers reported that a star in the constellation of Ophiuchus (known as RS Oph for short) had suddenly brightened and become visible even with the unaided eye in the night sky. Although this was the latest in a series of such outbursts of this star that have been spotted over the last hundred years or so, it was the first one since 1985 and gave scientists an opportunity to study it with new, more powerful, telescopes on the ground and in space.

RS Oph consists of a white dwarf, a super-dense dead star about the size of the Earth which was once the core of a star like the Sun and whose outer layers have been lost into space, in close orbit with a much larger, so-called red giant star. The two stars are so close together that the strong gravitational field of the white dwarf continuously pulls hydrogen-rich gas from the outer layers of the red giant. After around 20 years, so much gas builds up that a runaway thermonuclear explosion occurs on the white dwarf's surface. In less than a day, its energy output increases to over 100,000 times that of the Sun, and a quantity of gas equivalent to the mass of the Earth is ejected into space at speeds of several thousand kilometres per second (several million miles per hour).

Explosions such as this on short timescales of decades can only be explained if the white dwarf is near the maximum mass it could have without having collapsed to become an even denser object - a neutron star – during a supernova explosion.

What is also very unusual in RS Oph is that the red giant is losing enormous amounts of gas in a wind that envelops the whole system. As a result, the explosion on the white dwarf occurs effectively “inside” its companion's atmosphere and the ejected gas then slams into it at very high speed. Professor Bode explains “Immediately after the explosion, an observing campaign was set in train that involved most of the major space observatories, and many on the ground. We expected to see emission from the blast waves set up as the ejecta from the white dwarf impacted the red giant wind and we were not disappointed! For example, X-ray observations revealed temperatures in the shocked gas of over 100,000,000 degrees Celsius (around ten times that in the core of the Sun).”

On the ground, radio observations from telescopes spread around the globe also allowed the team to probe the initial stages of the outburst. Professor Bode comments, “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. Over the next few months we were surprised to find our radio observations apparently showing it turning from a ring into a cigar-like shape with two more extended blobs (“jets”) gradually emerging, one on either side.”

In order to determine more precisely what was happening, optical observations with the orbiting Hubble Space Telescope (HST) were made in July 2006. Dr Dan Harman of Liverpool JMU took on the task of analysing the resulting data. “The problem here was that, seen from a distance of 5,000 light years, we were looking for what would appear to be very tiny and very faint features buried within the glare from the bright central star – a bit like trying to read the registration (licence) plate of an approaching car with its headlights on at night. However, after carefully removing the confusing effects of the star we were astounded by the results”.

Professor Bode continues, “Archival images taken before the latest outburst show no extended structure, but our latest HST images clearly show what appear to be two overlapping rings of total extent around 0.4 seconds of arc in size. At a distance of 5,000 light years, that equates to 8 times the diameter of Pluto’s orbit around our Sun and an inferred speed of expansion from the time of the explosion of around 3,200 kilometres per second (over 7 million miles per hour). The overall size and orientation are consistent with continued expansion of the largest structures (so-called “jets”) seen in the later radio images, but the picture is, perhaps unsurprisingly, not the simple one that had been assumed prior to the 2006 outburst.”

What Mike Bode and the team think we may be seeing is emission from the boundary of a rapidly expanding region shaped something like a peanut, but inclined towards us at an angle of around 40 degrees. The central stars orbit around each other in the plane of the “waist” region and the rings we see are a natural consequence of us looking through this inclined structure. They are now working with astronomers in Mexico who have high resolution optical spectra taken from the ground at around the time of the HST observations, and with these they expect to be able to tie down the geometry more precisely. “Further scheduled HST observations should also help in this regard”, says Bode. As

Professor Sumner Starrfield adds, “The HST images clearly resolve the effects of high velocity material that has been explosively ejected from the white dwarf and then impacting the environment of the companion star: Star Wars in Action.”

The big question is what causes this shaping in the first place? It is thought unlikely that it originates in the explosion itself. More probable is that the environment into which the material is ejected is denser in some directions (most likely the plane of the binary star orbit) than others. This will have important wider implications for our understanding of the explosion and how jet-like structures are formed in many other astronomical objects.

Professor Bode was speaking on behalf of the team which also comprises Dan Harman and Matt Darnley (Liverpool JMU, UK), Tim O’Brien (Jodrell Bank Observatory, University of Manchester, UK), Howard Bond (Space Telescope Science Institute, USA), Sumner Starrfield (Arizona State University, USA), Nye Evans (University of Keele, UK), Stewart Eyres (University of Central Lancashire, UK) and Michael Shara (American Museum of Natural History, USA).

Source: Royal Astronomical Society

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