X-ray vision can reveal the moment of birth of violent supernovae

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A team of astronomers led by the University of Leicester has uncovered new evidence that suggests that X-ray detectors in space could be the first to witness new supernovae that signal the death of massive stars.

Astronomers have measured an excess of X-ray radiation in the first few minutes of collapsing massive stars, which may be the signature of the supernova shock wave first escaping from the star.

The findings have come as a surprise to Dr Rhaana Starling, of the University of Leicester Department of Physics and Astronomy whose research is published in the *Monthly Notices of the* Royal Astronomical Society, published by Oxford University Press.

Dr Starling said: "The most massive stars can be tens to a hundred times larger than the Sun. When one of these giants runs out of hydrogen gas it collapses catastrophically and explodes as a supernova, blowing off its outer layers which enrich the Universe. But this is no ordinary supernova; in the explosion narrowly confined streams of material are forced out of the poles of the star at almost the speed of light. These so-called relativistic jets give rise to brief flashes of energetic gamma-radiation called gamma-ray bursts, which are picked up by monitoring instruments in Space, that in turn alert astronomers."

Gamma-ray bursts are known to arise in stellar deaths because coincident supernovae are seen with ground-based optical telescopes about ten to twenty days after the high energy flash. The true moment of

birth of a supernova, when the star's surface reacts to the core collapse, often termed the supernova shock breakout, is missed. Only the most energetic supernovae go hand-in-hand with gamma-ray bursts, but for this sub-class it may be possible to identify X-ray emission signatures of the supernova in its infancy. If the supernova could be detected earlier, by using the X-ray early warning system, astronomers could monitor the event as it happens and pinpoint the drivers behind one of the most violent events in our Universe.

The X-ray detectors being used for this research, built partly in the UK at the University of Leicester, are on the X-Ray Telescope on-board the Swift satellite. Swift is named after the bird because, like its namesake, it is able to swiftly turn around to catch a gamma-ray burst in action. Data from Swift of a number of gamma-ray bursts with visible supernovae have shown an excess in X-rays received compared with expectations. This excess is thermal emission, also known as blackbody radiation.

Dr Starling added: "We were surprised to find thermal X-rays coming from a gamma-ray burst, and even more surprising is that all confirmed cases so far are those with a secure supernova identification from optical data. This phenomenon is only seen during the first thousand seconds of an event, and it is challenging to distinguish it from X-ray emission solely from the gamma-ray burst jet. That is why astronomers have not routinely observed this before, and only a small subset of the 700+ bursts we detect with Swift show it."

"It all hangs on the positive identification of the extra X-ray radiation as directly emerging from the supernova shock front, rather than from the relativistic jets or central black hole. If this radiation turns out to be from the central black-hole-powered engine of the gamma-ray burst instead, it will still be a very illuminating result for gamma-ray burst physics, but the strong association with supernovae is tantalising".

The team, comprising scientists from the UK, Ireland, USA and Denmark, plan to extend their searches, and make more quantitative comparisons with theoretical models both for stellar collapse and the dynamics of fast jet-flows.

Astronomers will continue to view supernovae at their visible-light peak, when they are already tens of days old, but for the most energetic among them it may become possible to routinely witness the very moment they are born, through X-ray eyes.

Provided by University of Leicester

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