

# THE *Current*

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## **Astronomers Watch Instant Replay of Powerful Stellar Eruption**

Astronomers are watching the astronomical equivalent of an instant replay of a spectacular outburst from the unstable, behemoth double-star system Eta Carinae, which was initially seen on Earth nearly 170 years ago. Astrophysicists affiliated with UC Santa Barbara and Las Cumbres Observatory Global Telescope Network (LCOGT) contributed to the study.

Dubbed the "Great Eruption," the outburst lasted from 1837 to 1858 and temporarily made Eta Carinae the second brightest star in the sky. But luckily for today's astronomers, some of the light from the eruption took an indirect path to Earth and is just arriving now. The wayward light was heading in a different direction, away from our planet, when it bounced off dust lingering far from the turbulent stars and was rerouted to Earth, an effect called a "light echo." Because of its longer path, the light reached Earth 170 years later than the light that arrived directly.

The team's paper will appear Feb. 16, in a letter to the journal *Nature*. Armin Rest of the Space Telescope Science Institute in Baltimore, Md., initially discovered the light echoes, and was the leader of the study.

Federica Bianco, a postdoctoral researcher at UCSB and LCOGT, used LCOGT's Faulkes Telescope South in Siding Spring, Australia, to record the explosion after this time delay and compare it to eyewitness reports of the brightness of the star from the 1800's to determine that the light echo was indeed from the "Great Eruption."

"You are at the stadium, watching the game, and your team scores," said Bianco. "But you are too far away to get the details of the action, or in the case of Eta Carinae's great eruption, you do not have modern instruments, detectors, and spectrographs to study it. Now we are getting a replay -- an up-close, detailed view of our cosmic eruption. And just like with the replay, we get to see the outburst from a different point of view, as the light that we see now was originally traveling in a different direction than the light seen in the 1840's."

Andy Howell, a staff scientist at LCOGT and adjunct faculty member at UCSB, adds, "We finally got to watch firsthand the event that created the iconic Hubble Space Telescope images of giant lobes of gas expanding away from Eta Carinae. It turns out it was an explosion -- and a strange, cool one. It just blows my mind that we can go back in time and watch one of astronomy's greatest hits, and greatest mysteries, with a cosmic instant replay."

The observations are providing new insight into the behavior of powerful massive stars on the brink of detonation. Very massive stars, especially a pair of them, are exceedingly rare, and little is known about how they lose mass as they die. The views of the nearby erupting star revealed some unexpected results, which will force astronomers to modify physical models of the outburst.

Located 8,000 light-years from Earth, Eta Carinae is one of the largest and brightest star systems in our Milky Way galaxy. Although the chaotic duo is known for its petulant outbursts, the Great Eruption was the biggest ever observed. During the 20-year episode, Eta Carinae shed some 20 solar masses. Some of the outflow formed the system's twin giant lobes. Before the epic event, the stellar pair was 140 times heftier than our Sun.

The team's study involved a mix of visible-light and spectroscopic observations from ground-based telescopes. These observations mark the first time astronomers have used spectroscopy to analyze a light echo from a star undergoing powerful recurring eruptions, though they have measured this unique phenomenon around exploding stars called supernovae. Spectroscopy captures a star's "fingerprints," providing details about its behavior, including the temperature and speed of the ejected material.

The replay is giving astronomers a unique look at the outburst, and turning up some surprises. The turbulent star does not behave like other stars of its class. Eta Carinae is a member of a stellar class called Luminous Blue Variables -- large, extremely bright stars that are prone to periodic outbursts.

The temperature of the outflow from Eta Carinae's central region, for example, is about 8,500 degrees Fahrenheit (5,000 Kelvin), which is much cooler than that of other erupting stars. "This star really seems to be an oddball," Rest said. "Now we have to go back to the models and see what has to change to actually produce what we are measuring."

The team first spotted the light echo while comparing visible-light observations they took of the star in 2010 and 2011 with the U.S. National Optical Astronomy Observatory's Blanco 4-meter telescope at the Cerro Tololo Inter-American Observatory (CTIO) in Chile. They obtained another set of CTIO observations taken in 2003 by astronomer Nathan Smith of the University of Arizona in Tucson, which helped them piece together the whole 20-year outburst.

The research group will continue monitoring Eta Carinae because light from the outburst is still streaming to Earth. "We should see brightening again in six months from another increase in light that was seen in 1844," Rest said. "We hope to capture light from the outburst coming from different directions so that we can get a complete picture of the eruption."

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† Middle image: These images reveal light from a massive stellar outburst in the Carina Nebula reflecting off dust clouds surrounding a behemoth double-star

system, a phenomenon called a light echo. The color image at left shows the Carina Nebula, a star-forming region located 7500 light-years from Earth. The massive star Eta Carinae resides near the top of the image. The double-star system, about 120 times more massive than the Sun, produced a spectacular outburst that was seen on Earth from 1837 to 1858. But some of the light from the eruption took an indirect path and is just now reaching our planet. The light bounced off dust clouds (the box about 100 light-years away at the bottom of the image) and was rerouted to Earth. The image was taken by the U.S. National Optical Astronomy Observatory's Curtis-Schmidt Telescope at the Cerro Tololo Inter American Observatory (CTIO) in Chile.

The three black-and-white images at right show light from the eruption illuminating the dust clouds over an eight-year span as it moves through them. The effect is like shining a flashlight on different regions of a vast cavern. The images were taken by the U.S. National Optical Astronomy Observatory's Blanco 4-meter telescope at the CTIO.

Credit: NASA, NOAO, A. Rest (STScI), and N. Smith (U. Arizona)

**††** Bottom image: A Hubble Space Telescope image of the massive binary star system Eta Carinae taken in 1995.

The pair of stars are hidden, but give off the white-blue glow at the center of the image.

The hourglass shape is due to two huge lobes of gas expanding outward, a product of the mid-1800s Great Eruption that was studied as a light echo in Rest et al.

Credit: Jon Morse (University of Colorado), and NASA

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