

[kd 2021/06/05]

## MOST POWERFUL STAR IN OUR PART OF THE GALAXY EMERGES FROM TWO CENTURIES OF DISRUPTION, HUBBLE DATA SHOWS

Kris Davidson, University of Minnesota    kd@umn.edu

John C. Martin, University of Illinois at Springfield    jmart5@uis.edu

Kazunori Ishibashi, Nagoya University    bish@nagoya-u.jp

Roberta M. Humphreys, University of Minnesota    roberta@umn.edu

Release date: Tuesday 4 p.m. EDT

Recent data from the Hubble Space Telescope shows that Eta Carinae, the most massive star within 10,000 lightyears of us, has finally returned to a semi-normal state almost 200 years after its unparalleled explosion. Eta was one of the brightest stars in the sky from 1830 to 1855, but later faded from naked-eye view. After a bewildering series of changes, it again became visible a few years ago, and today its spectrum looks almost like a different star compared to 2000. It has nearly returned to the state seen before its supernova-like event.

[For details about Eta's location, visibility, etc., see notes at end of this text.]

For several decades, astronomers have been mystified by "supernova impostors" or giant eruptions, massive stellar outbursts that resemble supernova explosions but do not destroy the stars. Instead of nuclear reactions, they're driven by horrendously complex instabilities that arise when radiation pressure becomes too strong. Generically, supernova impostors are far more mysterious than true supernovae. They are extremely rare, and nearly all known examples occurred in galaxies millions of lightyears away.

Eta Carinae is the big exception: it's the only giant eruption survivor close enough to study in detail. It weighs more than 120 times the Sun, putting it in a one-in-ten-billion category among stars. Between 1830 and 1855, Eta released more light than the Sun has radiated in the entire time since the dinosaurs. After fading from naked-eye view around 1860, Eta exhibited three unexplained episodes of rapid brightening. The most recent began in the 1990's and was first noticed in HST data (= Hubble Space Telescope). The star's spectrum then showed a major change of state between 1998 and 2010; its immense rate of mass loss rapidly declined to a level more like other massive stars. (HST has been needed because ground-based telescopes cannot separate the star from its bright nearby ejecta.)

Equally extraordinary, Eta Carinae has a companion star in a highly eccentric 5.5-year orbit. When this smaller, hotter companion passes closest to the major star, the mass outflow from the latter is briefly altered by tidal and radiative forces. Observing one of those events is almost like doing a lab experiment, altering parameters to see what happens. Three instances were observed with HST in 2003, 2014, and 2020. *The 2014 and 2020 events turned out to be very different from 2003.* They showed very strong extreme-UV radiation, which had vanished in every earlier event of this type.

So far as we can tell at this time, the companion gathered some mass from the bigger star in every close-approach event through 2003. In 2014 and 2020, however, it did not; this means that the mass outflow has fallen below a critical rate. Before 2000, material gushed out of Eta Carinae at a rate of about 1/1000 of a solar mass per year -- the highest long-term rate of any well-documented star. Since 2010, it has dropped to roughly 1/4000 solar mass per year -- still unusual, but less than some red hypergiant stars.

Long before the giant eruption, Edmond Halley observed Eta Carinae as a fourth-magnitude star, moderately faint but easy to see with good eyes and a dark sky. Today HST shows that it has recently become almost half that bright again and it now has a semi-normal stellar wind instead of a phenomenal mass outflow. In the next 10 or 20 years, when the dust has cleared a little more, it'll be essentially back to normal. Meanwhile, the surrounding 180-year-old ejecta will be the brightest compact nebula in the sky, as seen in a good telescope.

[Location, visibility, etc.: Eta Carinae is located 7500 lightyears away, in the Carina spiral arm of our Milky Way Galaxy. It radiates about 5 million times as much light as the Sun, more than any other star that we're really sure about, but much of the light is converted to infrared in the surrounding nebula. Because it's 7500 lightyears away, many people have speculated that the star may already have been destroyed as a giant supernova but light from the event has not yet reached us -- we do not yet know whether that idea is likely or not. ... Unfortunately, Eta is in the far southern sky, visible only south of latitude 25N. It's probably the farthest individual star that can definitely be seen with normal eyesight. When viewed with a fairly large telescope, during the past 30 years it has become one of the most spectacular sights in the sky because of its "Homunculus," a massive nebula of material ejected from Eta, often shown in collections of astronomy images. In a telescope the Homunculus nebula has about the same apparent size as the planet Saturn.]

#### ----- Supplementary material

\* For images and general information about Eta Carinae and supernova impostors, see <http://etacar.umn.edu/>. Unfortunately this website has become slightly out of date, but it is far more accurate than most internet sites.

\* We hope to post figures for the above news item on that site, but have not yet done so as of Sunday afternoon. Try <http://etacar.umn.edu/download/AAS238/> .

\* The famous HST images of Eta Carinae's Homunculus Nebula, and the surrounding Great Carina Nebula NGC 3372, are ubiquitous on general astronomy sites such as Astronomy Picture of the Day.

\* Avoid Wikipedia!! For topics that are familiar to less than 1000 people, Wikipedia often contains misinformation -- this is a well-known fact of life and it's easy to guess the reasons. The most massive stars, giant stellar eruptions, and Eta Carinae are in that category.

-----