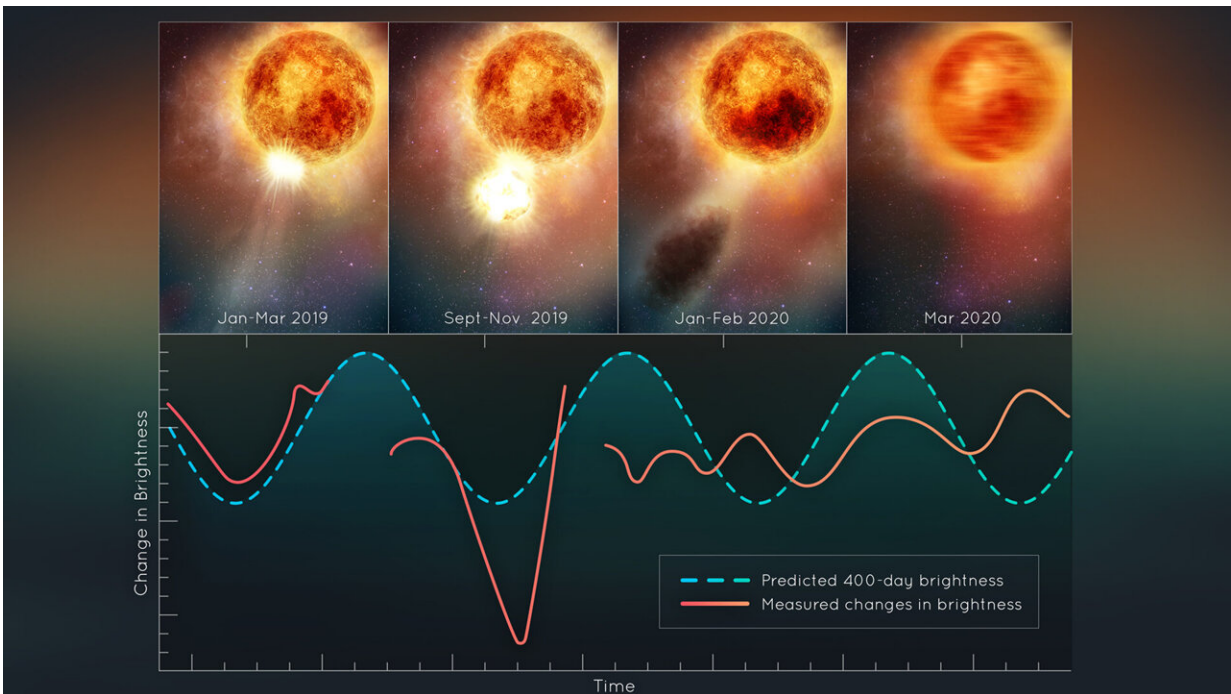


Hubble sees supergiant Betelgeuse slowly recovering after blowing its top

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This illustration plots changes in brightness of the red supergiant star Betelgeuse, following the titanic mass ejection of a large piece of its visible surface. The escaping material cooled to form a cloud of dust that temporarily made the star look dimmer, as seen from Earth. This unprecedented stellar convulsion disrupted the monster star's 400-day-long oscillation period that astronomers had measured for more than 200 years. The interior may now be jiggling like a plate of gelatin dessert. Credit: NASA, ESA, Elizabeth Wheatley (STScI)

Analyzing data from NASA's Hubble Space Telescope and several other observatories, astronomers have concluded that the bright red supergiant star Betelgeuse quite literally blew its top in 2019, losing a substantial part of its visible surface and producing a gigantic Surface Mass Ejection (SME). This is something never before seen in a normal star's behavior.

The sun routinely blows off parts of its tenuous outer atmosphere, the corona, in an event known as a Coronal Mass Ejection (CME). But the Betelgeuse SME blasted off 400 billion times as much mass as a typical CME.

The monster star is still slowly recovering from this catastrophic upheaval. "Betelgeuse continues doing some very unusual things right now; the interior is sort of bouncing," says Andrea Dupree of the Center for Astrophysics | Harvard & Smithsonian.

These new observations yield clues as to how red stars lose mass late in their lives as their nuclear fusion furnaces burn out, before exploding as supernovae. The amount of mass loss significantly affects their fate. However, Betelgeuse's surprisingly petulant behavior is not evidence the star is about to blow up anytime soon. So the mass loss event is not necessarily the signal of an imminent explosion.

Dupree is now pulling together all the puzzle pieces of the star's petulant behavior before, after, and during the eruption into a coherent story of a never-before-seen titanic convulsion in an aging star.

This includes new spectroscopic and imaging data from the STELLA robotic observatory, the Fred L. Whipple Observatory's Tillinghast Reflector Echelle Spectrograph (TRES), NASA's Solar Terrestrial Relations Observatory spacecraft (STEREO-A), NASA's Hubble Space Telescope, and the American Association of Variable Star Observers

(AAVSO). Dupree emphasizes that the Hubble data was pivotal to helping sort out the mystery.

"We've never before seen a huge mass ejection of the surface of a star," she says. "We are left with something going on that we don't completely understand. It's a totally new phenomenon that we can observe directly and resolve surface details with Hubble. We're watching stellar evolution in real time."

The titanic outburst in 2019 was possibly caused by a convective plume, more than a million miles across, bubbling up from deep inside the star. It produced shocks and pulsations that blasted off the chunk of the photosphere leaving the star with a large cool surface area under the dust cloud that was produced by the cooling piece of photosphere. Betelgeuse is now struggling to recover from this injury.

Weighing roughly several times as much as our moon, the fractured piece of photosphere sped off into space and cooled to form a [dust cloud](#) that blocked light from the star as seen by Earth observers. The dimming, which began in late 2019 and lasted for a few months, was easily noticeable even by backyard observers watching the star change brightness. One of the brightest stars in the sky, Betelgeuse is easily found in the right shoulder of the constellation Orion.

Even more fantastic, the supergiant's 400-day pulsation rate is now gone, perhaps at least temporarily. For almost 200 years astronomers have measured this rhythm as evident in changes in Betelgeuse's brightness variations and surface motions. Its disruption attests to the ferocity of the blowout.

The star's interior convection cells, which drive the regular pulsation may be sloshing around like an imbalanced washing machine tub, Dupree suggests. TRES and Hubble spectra imply that the outer layers

may be back to normal, but the surface is still bouncing like a plate of gelatin dessert as the photosphere rebuilds itself.

Though the sun has [coronal mass ejections](#) that blow off small pieces of the outer atmosphere, astronomers have never witnessed such a large amount of a star's visible surface get blasted into space. Therefore, surface mass ejections and coronal mass ejections may be different events.

Betelgeuse is now so huge now that if it replaced the sun at the center of our solar system, its outer surface would extend past the orbit of Jupiter. Dupree used Hubble to resolve hot spots on the star's [surface](#) in 1996. This was the first direct image of a star other than the sun.

NASA's Webb Space Telescope may be able to detect the ejected material in [infrared light](#) as it continues moving away from the star.

Provided by Harvard-Smithsonian Center for Astrophysics

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