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EXPOSING THE INTERSTELLAR MEDIUM

The penetrating eye of JWST brings Cassiopeia A's surroundings into focus. BY RICHARD TALCOTT

ROUGHLY 11,000 YEARS AGO, a massive star in the constellation Cassiopeia reached the end of its all-too-brief life. When the star's iron core collapsed, it triggered a shock wave that ripped the rest of the star apart and lit up its small corner of the galaxy.

Unfortunately for earthbound observers, thick dust clouds in the Milky Way absorbed most of the supernova's light, and what little got through failed to make an impression when it reached our planet some 350 years ago. The first definitive sighting came in the 1940s, when radio astronomers detected its remnant as the brightest radio source in Cassiopeia. That distinction earned it the name Cassiopeia A (Cas A for short). Optical astronomers didn't spot the remnant until a few years later in 1950.

A PERFECT LABORATORY

At a distance of only 11,000 light-years, Cas A makes an ideal target for studying a supernova and its aftermath. The James Webb Space Telescope (JWST) has viewed Cas A several times in the past three years. Early on, it concentrated on the 10-light-year-wide shell of material the explosion ejected. (See "A tangled web of debris" in the October 2023 issue.)

Now, astronomers have shifted their focus to the interstellar medium well beyond the remnant's sphere of influence. Jacob Jencson of IPAC at Caltech in Pasadena, California, led a team that used JWST to explore the dusty environment surrounding Cas A. The researchers reported their findings at the January meeting of the American Astronomical Society in National Harbor, Maryland.

When the explosion's original shock wave breached the star's surface, it generated an intense burst of X-rays and ultraviolet radiation that continues to spread out at the speed of light. As that pulse of energy encounters interstellar gas and dust, it warms the material enough for it to glow at infrared wavelengths — right in JWST's wheelhouse. In essence, we see the supernova's initial burst reverberating across the interstellar medium as a thermal light echo.

Jencson's team targeted a light echo some 230 light-years from the Cas A remnant. The scientists viewed the echo three times from Aug. 19 to Sept. 30, 2024, watching for changes that will help illuminate the interstellar medium's 3D structure.

"We were pretty shocked to see this level of detail," said Jencson. JWST resolves the structures into fine filaments that appear to be sculpted by magnetic fields. The telescope reveals features as small as 400 astronomical units across, or just five times the diameter of Pluto's orbit around the Sun. (One astronomical unit, or AU, is the average Earth-Sun distance of 93 million miles [150 million kilometers].)

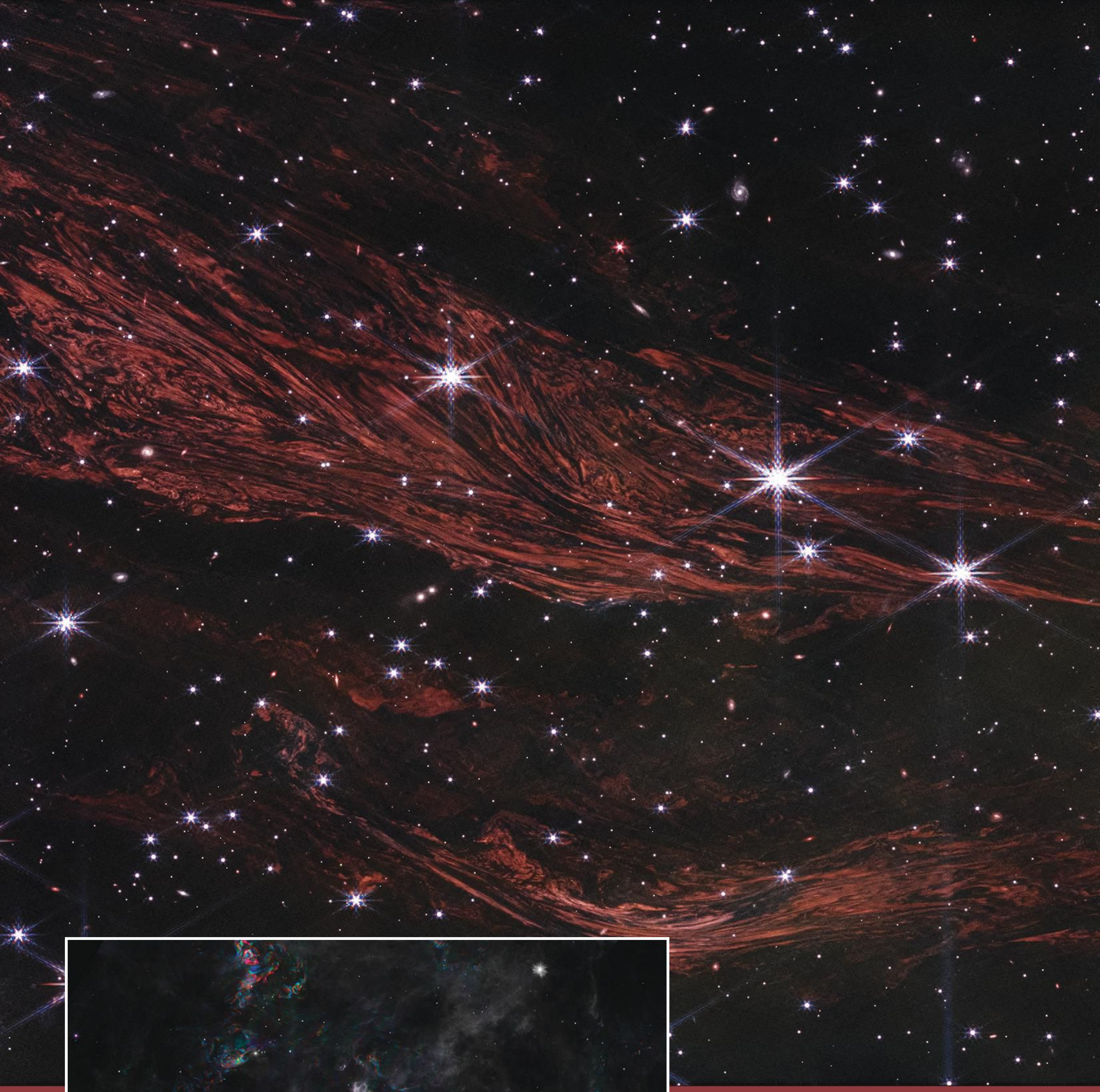
"We did not know that the interstellar medium had structures on that small of a scale," added team member Josh Peek of the Space Telescope Science Institute in Baltimore. "We think every dense, dusty region that we see, and most of the ones we don't see, look like this on the inside."

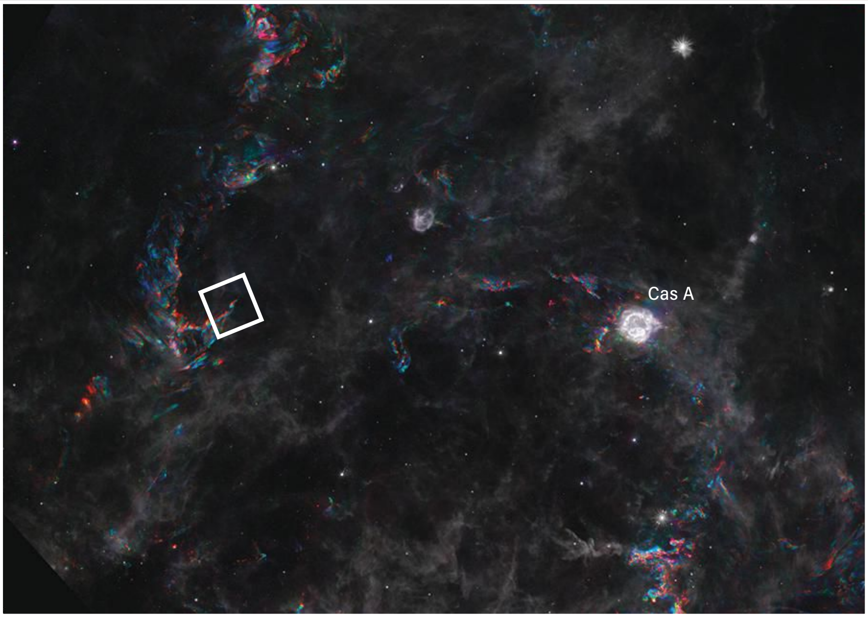
WHAT LIES AHEAD

The astronomers will continue imaging Cas A's light echoes, and also plan to take spectra of the glowing material. Spectroscopy should open a new window into the structure of the interstellar medium surrounding Cas A.

"We can observe the same patch of dust before, during, and after it's illuminated by the echo and try to look for any changes in the compositions or states of the molecules, including whether some molecules or even the smallest dust grains are destroyed," said Jencson.

Contributing Editor ***Richard Talcott*** *wrote about JWST's observations of planet-forming disks in the Small Magellanic Cloud in the June issue.*





ABOVE: Tightly packed ribbons glow in infrared light as gas and dust radiate from the effects of the supernova blast that created Cassiopeia A. JWST captured this thermal light echo Aug. 19, 2024, the first of three observations to look for changes in the interstellar medium. NASA, ESA, CSA, STSCI, JACOB JENCSON (CALTECH/IPAC)

LEFT: NASA's Spitzer Space Telescope took a series of six infrared images of Cassiopeia A and its surroundings from 2005 to 2008. In this composite, dust features in blue and orange represent changes as light echoes spread outward; gray areas showed no changes. The square highlights the area JWST imaged at high resolution. NASA/JPL-CALTECH/Y. KIM (UNIV. OF ARIZONA/UNIV. OF CHICAGO)