

The Crab Nebula seen in new light by NASA's Webb

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NASA's James Webb Space Telescope has gazed at the Crab Nebula in the search for answers about the supernova remnant's origins. Webb's NIRCам (Near-Infrared Camera) and MIRI (Mid-Infrared Instrument) have revealed new

details in infrared light. Similar to the Hubble optical wavelength image released in 2005, with Webb the remnant appears comprised of a crisp, cage-like structure of fluffy red-orange filaments of gas that trace doubly ionized sulfur (sulfur III). Among the remnant's interior, yellow-white and green fluffy ridges form large-scale loop-like structures, which represent areas where dust particles reside. The area within is comprised of translucent, milky material. This white material is synchrotron radiation, which is emitted across the electromagnetic spectrum but becomes particularly vibrant thanks to Webb's sensitivity and spatial resolution. It is generated by particles accelerated to extremely high speeds as they wind around magnetic field lines. Trace the synchrotron radiation throughout the majority of the Crab Nebula's interior. Locate the wisps that follow a ripple-like pattern in the middle. In the center of this ring-like structure is a bright white dot: a rapidly rotating neutron star. Further out from the core, follow the thin white ribbons of the radiation. The curvy wisps are closely grouped together, following different directions that mimic the structure of the pulsar's magnetic field. Note how certain gas filaments are bluer in color. These areas contain singly ionized iron (iron II). Credit: Image NASA, ESA, CSA, STScI, Tea Temim (Princeton University)

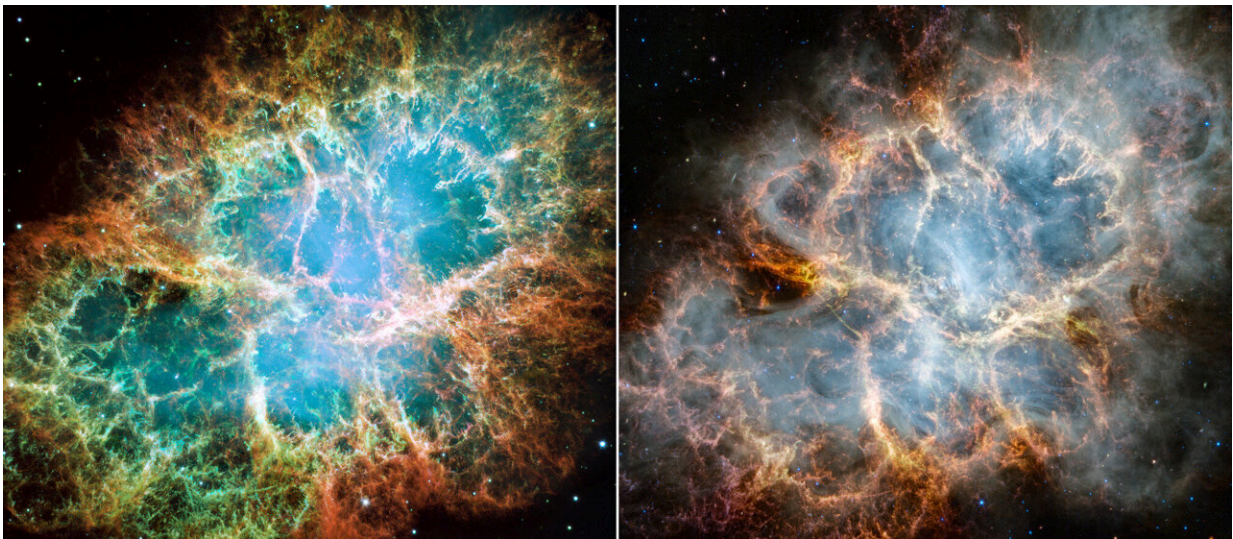
Exquisite, never-before-seen details help unravel the supernova remnant's puzzling history.

NASA's James Webb Space Telescope has gazed at the Crab Nebula, a supernova remnant located 6,500 light-years away in the constellation Taurus. Since the recording of this energetic event in 1054 C.E. by 11th-century astronomers, the Crab Nebula has continued to draw attention and additional study as scientists seek to understand the conditions, behavior, and after-effects of supernovae through thorough study of the Crab, a relatively nearby example.

Using Webb's NIRCam (Near-Infrared Camera) and MIRI (Mid-Infrared Instrument), a team led by Tea Temim at Princeton University is searching for answers about the Crab Nebula's origins.

"Webb's sensitivity and [spatial resolution](#) allow us to accurately determine the composition of the ejected material, particularly the content of iron and nickel, which may reveal what type of explosion produced the Crab Nebula," explained Temim.

At first glance, the general shape of the supernova remnant is similar to the optical wavelength image released in 2005 from NASA's Hubble Space Telescope: In Webb's infrared observation, a crisp, cage-like structure of fluffy gaseous filaments is shown in red-orange. However, in the central regions, emission from dust grains (yellow-white and green) is mapped out by Webb for the first time.



A side-by-side comparison of the Crab Nebula as seen by the Hubble Space Telescope in optical light (left) and the James Webb Space Telescope in infrared light (right). The Hubble image was released in 2005, while astronomers have recently used Webb's NIRCam (Near-Infrared Camera) and MIRI (Mid-Infrared Instrument) to reveal new details of the Crab Nebula. In the Hubble image, orange filaments consisting mostly of hydrogen form a crisp, cage-like exterior shell. Blue mottled filaments toward the outer part of the Crab contain neutral oxygen, while singly-ionized sulfur and doubly-ionized sulfur form fluffy red and green material. The bright glow in the interior's center highlights the nebula's

pulsar, a rapidly rotating neutron star. Similar to the Hubble optical image, Webb's infrared capabilities show the supernova remnant's crisp, cage-like structure of fluffy red-orange filaments of gas that trace doubly ionized sulfur. Among the remnant's interior, yellow-white and green fluffy ridges form large-scale loop-like structures, which represent areas where dust particles reside. The central area within is comprised of translucent, milky material. This white material is synchrotron radiation, which is emitted across the electromagnetic spectrum but becomes particularly vibrant thanks to Webb's sensitivity and spatial resolution. It is generated by particles accelerated to extremely high speeds as they wind around magnetic field lines. In the center of this ring-like structure is a bright white dot: the nebula's pulsar. Note how certain gas filaments are bluer in color. These areas contain singly ionized iron. By studying Webb data and consulting previous observations of the remnant taken by other telescopes, like Hubble, astronomers can improve their understanding of the Crab Nebula as well as broaden their knowledge on the life and death of stars. Credit: Image: NASA, ESA, CSA, STScI, Jeff Hester (ASU), Allison Loll (ASU), Tea Temim (Princeton University)

Additional aspects of the inner workings of the Crab Nebula become more prominent and are seen in greater detail in the infrared light captured by Webb. In particular, Webb highlights what is known as [synchrotron radiation](#): emission produced from charged particles, like electrons, moving around magnetic field lines at relativistic speeds. The radiation appears here as milky smoke-like material throughout the majority of the Crab Nebula's interior.

This feature is a product of the nebula's pulsar, a rapidly rotating neutron star. The pulsar's strong magnetic field accelerates particles to extremely high speeds and causes them to emit radiation as they wind around [magnetic field lines](#). Though emitted across the [electromagnetic spectrum](#), the synchrotron radiation is seen in unprecedented detail with Webb's NIRCam instrument.

To locate the Crab Nebula's pulsar heart, trace the wisps that follow a circular ripple-like pattern in the middle to the bright white dot in the center. Farther out from the core, follow the thin white ribbons of the radiation. The curvy wisps are closely grouped together, outlining the structure of the pulsar's magnetic field, which sculpts and shapes the nebula.

At center left and right, the white material curves sharply inward from the filamentary dust cage's edges and goes toward the neutron star's location, as if the waist of the [nebula](#) is pinched. This abrupt slimming may be caused by the confinement of the supernova wind's expansion by a belt of dense gas.

The wind produced by the pulsar heart continues to push the shell of gas and dust outward at a rapid pace. Among the remnant's interior, yellow-white and green mottled filaments form large-scale loop-like structures, which represent areas where dust grains reside.

The search for answers about the Crab Nebula's past continues as astronomers further analyze the Webb data and consult previous observations of the remnant taken by other telescopes. Scientists will have newer Hubble data to review within the next year or so from the telescope's reimaging of the supernova remnant. This will mark Hubble's first look at emission lines from the Crab Nebula in over 20 years, and will enable astronomers to more accurately compare Webb and Hubble's findings.

Provided by NASA

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