Webb captures iconic Horsehead Nebula in unprecedented detail

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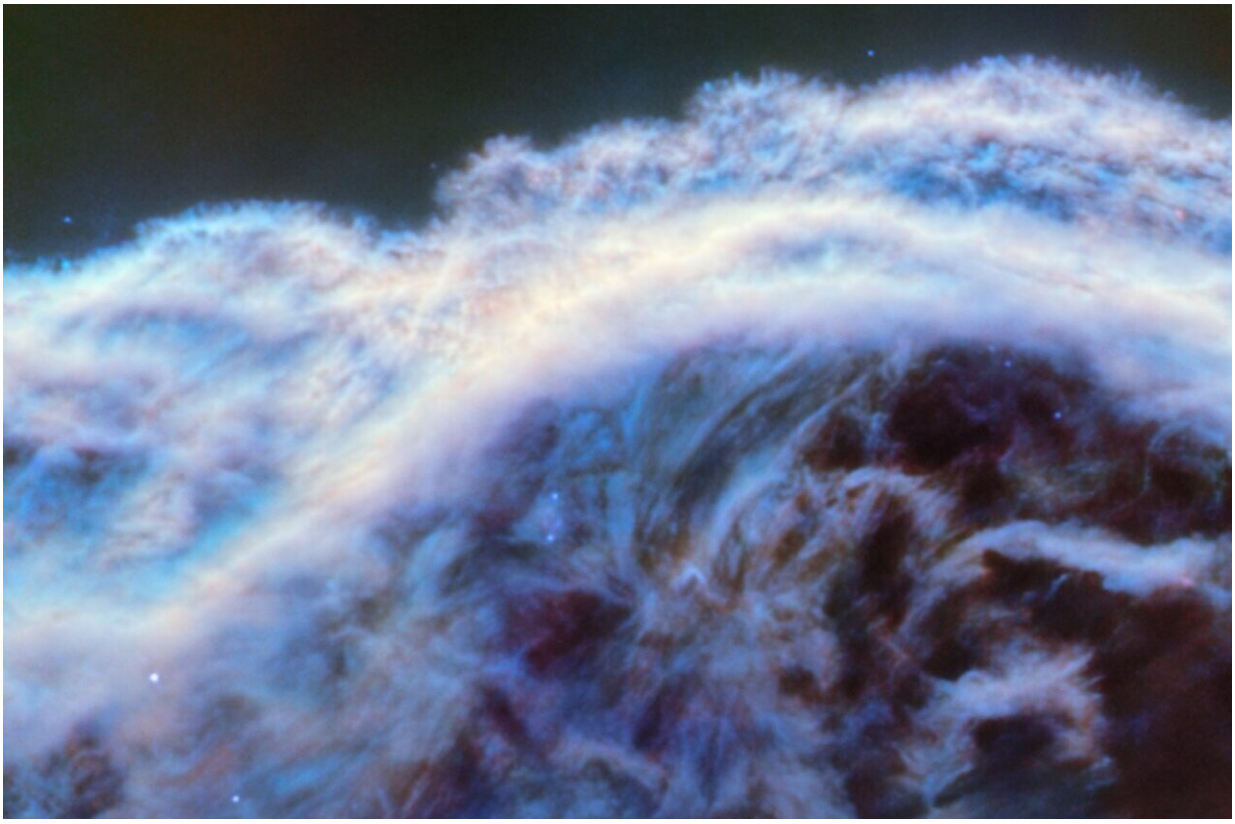


The image is more than half-filled by a small section of the Horsehead Nebula, from the bottom up. The clouds are seen up close, showing thick, whitish streaks and dark voids, as well as textured, fuzzy-looking patterns of dust and gas. The nebula stops at a spiky edge that follows a slight curve. Above it a small number of distant stars and galaxies lie on a dark but multi-colored background. Credit: ESA/Webb, NASA, CSA, K. Misselt (University of Arizona) and A. Abergel (IAS/University Paris-Saclay, CNRS)

The NASA/ESA/CSA James Webb Space Telescope has captured the sharpest infrared images to date of one of the most distinctive objects in our skies, the Horsehead Nebula. These observations show a part of the iconic nebula in a whole new light, capturing its complexity with unprecedented spatial resolution.

Webb's new images show part of the sky in the constellation Orion (The Hunter), in the western side of the Orion B molecular cloud. Rising from turbulent waves of dust and gas is the Horsehead Nebula, otherwise known as Barnard 33, which resides roughly 1,300 light-years away.

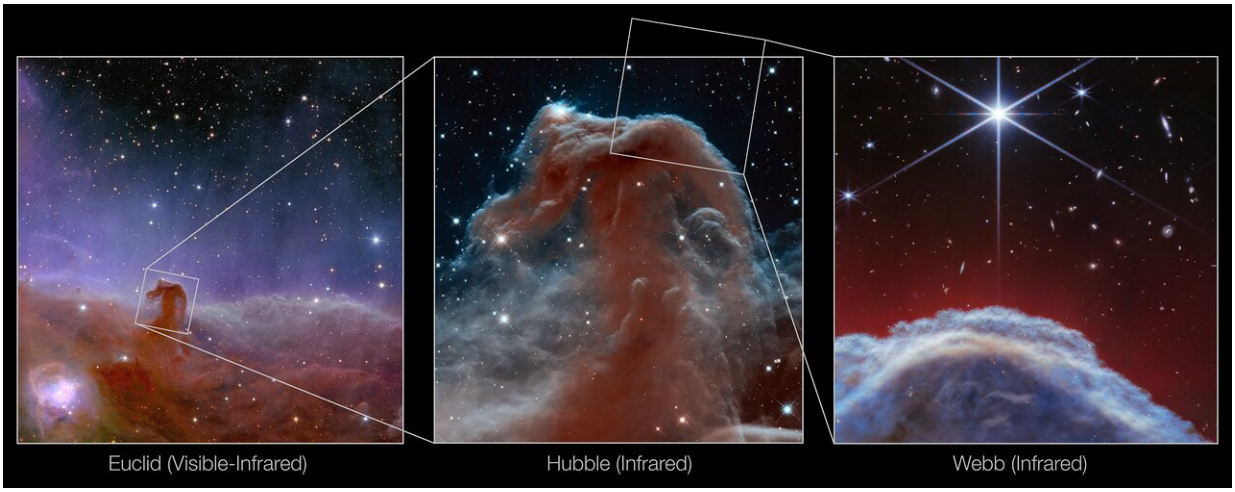
The nebula formed from a collapsing interstellar cloud of material, and glows because it is illuminated by a nearby hot star. The gas clouds surrounding the Horsehead have already dissipated, but the jutting pillar is made of thick clumps of material that is harder to erode. Astronomers estimate that the Horsehead has about 5 million years left before it too disintegrates. Webb's new view focuses on the illuminated edge of the top of the nebula's distinctive dust and gas structure.

The Horsehead Nebula is a well-known photodissociation region, or PDR. In such a region ultraviolet light from young, massive stars creates a mostly neutral, warm area of gas and dust between the fully ionized gas surrounding the massive stars and the clouds in which they are born. This ultraviolet radiation strongly influences the gas chemistry of these regions and acts as the most important source of heat.

These regions occur where interstellar gas is dense enough to remain neutral, but not dense enough to prevent the penetration of far-ultraviolet light from massive stars. The light emitted from such PDRs provides a unique tool to study the physical and chemical processes that drive the evolution of interstellar matter in our galaxy, and throughout the universe from the early era of vigorous star formation to the present day.

Due to its proximity and its nearly edge-on geometry, the Horsehead Nebula is an ideal target for astronomers to study the physical structures of PDRs and the evolution of the chemical characteristics of the gas and dust within their respective environments, and the transition regions between them. It is considered one of the best objects in the sky to study how radiation interacts with interstellar matter.

Thanks to Webb's MIRI and NIRCam instruments, an international team of astronomers have revealed for the first time the small-scale structures of the illuminated edge of the Horsehead. They have also detected a network of striated features extending perpendicular to the PDR front and containing dust particles and ionized gas entrained in the photo-evaporative flow of the nebula. The observations have also allowed astronomers to investigate the effects of dust attenuation and emission, and to better understand the multidimensional shape of the nebula.



A collage of three images of the Horsehead Nebula. In the left image labeled "Euclid (Visible-Infrared)", the Nebula is seen among its surroundings. A small box around it connects to the second image labeled "Hubble (Infrared)", where the Nebula is zoomed in on. A portion of the Nebula's head has another box, which leads with a callout to the third image, labeled "Webb (Infrared)", of that

area. Credit: ESA/Euclid/Euclid Consortium/NASA, image processing by J.-C. Cuillandre (CEA Paris-Saclay), G. Anselmi, NASA, ESA, and the Hubble Heritage Team (AURA/STScI), ESA/Webb, CSA, K. Misselt (University of Arizona) and A. Abergel (IAS/University Paris-Saclay, CNRS), M. Zamani (ESA/Webb)

Next, astronomers intend to study the spectroscopic data that have been obtained of the nebula to evidence the evolution of the physical and chemical properties of the material observed across the nebula.

These observations were taken in the Webb GTO program #1192 (PI: K. Misselt) and the results have been accepted for publication in *Astronomy & Astrophysics*.

More information: A. Abergel et al, JWST observations of the Horsehead photon-dominated region I. First results from multi-band near- and mid-infrared imaging, *Astronomy & Astrophysics* (2024). DOI: 10.1051/0004-6361/202449198

A. Abergel et al, JWST observations of the Horsehead photon-dominated region I. First results from multi-band near- and mid-infrared imaging, *arXiv* (2024). DOI: 10.48550/arxiv.2404.15816 , arxiv.org/abs/2404.15816

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