Webb captures a cosmic tarantula

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In this mosaic image stretching 340 light-years across, Webb's Near-Infrared Camera (NIRCam) displays the Tarantula Nebula star-forming region in a new light, including tens of thousands of never-before-seen young stars that were previously shrouded in cosmic dust. The most active region appears to sparkle with massive young stars, appearing pale blue. Scattered among them are still-embedded stars, appearing red, yet to emerge from the dusty cocoon of the nebula. NIRCam is able to detect these dust-enshrouded stars thanks to its unprecedented resolution at near-infrared wavelengths. To the upper left of the cluster of young stars, and the top of the nebula's cavity, an older star prominently displays NIRCam's distinctive eight diffraction spikes, an artifact of the telescope's structure. Following the top central spike of this star upward, it almost points to a distinctive bubble in the cloud. Young stars still surrounded by

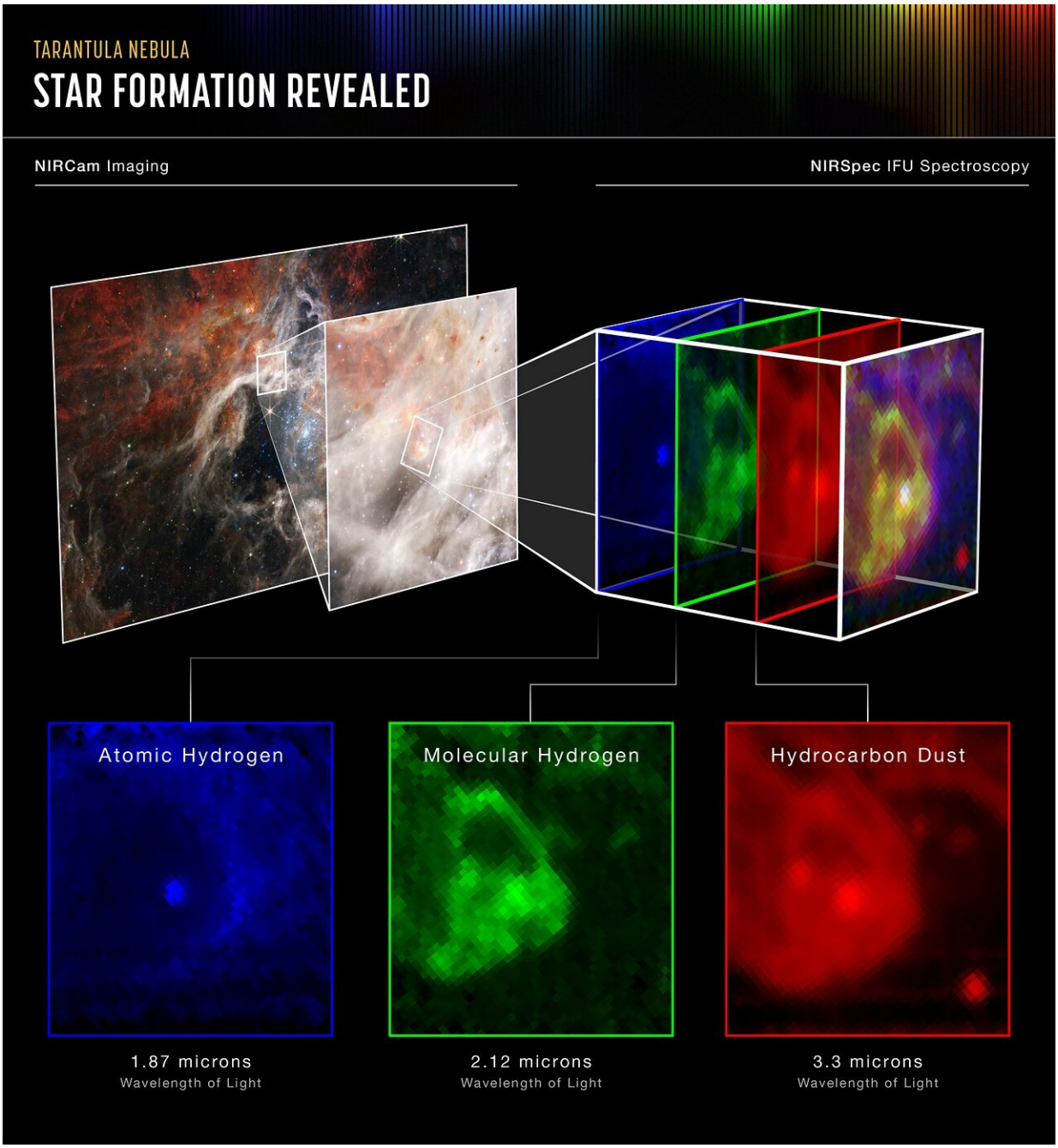
dusty material are blowing this bubble, beginning to carve out their own cavity. Astronomers used two of Webb's spectrographs to take a closer look at this region and determine the chemical makeup of the star and its surrounding gas. This spectral information will tell astronomers about the age of the nebula and how many generations of star birth it has seen. Farther from the core region of hot young stars, cooler gas takes on a rust color, telling astronomers that the nebula is rich with complex hydrocarbons. This dense gas is the material that will form future stars. As winds from the massive stars sweep away gas and dust, some of it will pile up and, with gravity's help, form new stars. Credit: NASA, ESA, CSA, and STScI

Thousands of never-before-seen young stars are spotted in a stellar nursery called 30 Doradus, captured by the NASA/ESA/CSA James Webb Space Telescope. Nicknamed the Tarantula Nebula for the appearance of its dusty filaments in previous telescope images, the nebula has long been a favorite for astronomers studying star formation. In addition to young stars, Webb reveals distant background galaxies, as well as the detailed structure and composition of the nebula's gas and dust.

At only 161,000 light-years away in the Large Magellanic Cloud galaxy, the Tarantula Nebula is the largest and brightest star-forming region in the Local Group, the galaxies nearest to our Milky Way. It is home to the hottest, most massive stars known. Astronomers focused three of Webb's high-resolution infrared instruments on the Tarantula. Viewed with Webb's Near-Infrared Camera (NIRCam), the region resembles a burrowing tarantula's home, lined with its silk. The nebula's cavity centered in the NIRCam image has been hollowed out by blistering radiation from a cluster of massive young stars, which sparkle pale blue in the image. Only the densest surrounding areas of the nebula resist erosion by these stars' powerful stellar winds, forming pillars that appear to point back toward the cluster. These pillars contain forming

protostars, which will eventually emerge from their dusty cocoons and take their turn shaping the nebula.

Webb's Near-Infrared Spectrograph (NIRSpec) caught one very young star doing just that. Astronomers previously thought this star might be a bit older and already in the process of clearing out a bubble around itself. However, NIRSpec showed that the star was only just beginning to emerge from its pillar and still maintained an insulating cloud of dust around itself. Without Webb's high-resolution spectra at infrared wavelengths, this episode of star formation-in-action could not have been revealed.



Webb's Near-Infrared Spectrograph (NIRSpec) reveals what is really going on in an intriguing region of the Tarantula Nebula. Astronomers focused the powerful instrument on what looked like a small bubble feature in the image from Webb's Near-Infrared Camera (NIRCam). However, the spectra reveal a very different picture from a young star blowing a bubble in its surrounding gas. The signature of atomic hydrogen, shown in blue, shows up in the star itself but not

immediately surrounding it. Instead, it appears outside the “bubble,” which spectra show is actually “filled” with molecular hydrogen (green) and complex hydrocarbons (red). This indicates that the bubble is actually the top of a dense pillar of dust and gas that is being blasted by radiation from the cluster of massive young stars to its lower right (see the full NIRCam image). It does not appear as pillar-like as some other structures in the nebula because there is not much color contrast with the area surrounding it. The harsh stellar wind from the massive young stars in the nebula is breaking apart molecules outside the pillar, but inside they are preserved, forming a cushy cocoon for the star. This star is still too young to be clearing out its surroundings by blowing bubbles – NIRSpec has captured it just beginning to emerge from the protective cloud from which it was formed. Without Webb’s resolution at infrared wavelengths, the discovery of this star birth in action would not have been possible. Credit: NASA, ESA, CSA, and STScI

The region takes on a different appearance when viewed in the longer infrared wavelengths detected by Webb's Mid-infrared Instrument (MIRI). The hot stars fade, and the cooler gas and dust glow. Within the stellar nursery clouds, points of light indicate embedded protostars, still gaining mass. While shorter wavelengths of light are absorbed or scattered by dust grains in the nebula, and therefore never reach Webb to be detected, longer mid-infrared wavelengths penetrate that dust, ultimately revealing a previously unseen cosmic environment.

One of the reasons the Tarantula Nebula is interesting to astronomers is that the nebula has a similar type of chemical composition as the gigantic star-forming regions observed at the universe's "cosmic noon," when the cosmos was only a few billion years old and star formation was at its peak. Star-forming regions in our Milky Way galaxy are not producing stars at the same furious rate as the Tarantula Nebula, and have a different chemical composition. This makes the Tarantula the closest (i.e., easiest to see in detail) example of what was happening in the

universe as it reached its brilliant high noon. Webb will provide astronomers the opportunity to compare and contrast observations of star formation in the Tarantula Nebula with the telescope's deep observations of distant galaxies from the actual era of cosmic noon.

Despite humanity's thousands of years of stargazing, the star formation process still holds many mysteries—many of them due to our previous inability to get crisp images of what was happening behind the thick clouds of stellar nurseries. Webb has already begun revealing a universe never seen before, and is only getting started on rewriting the stellar creation story.

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