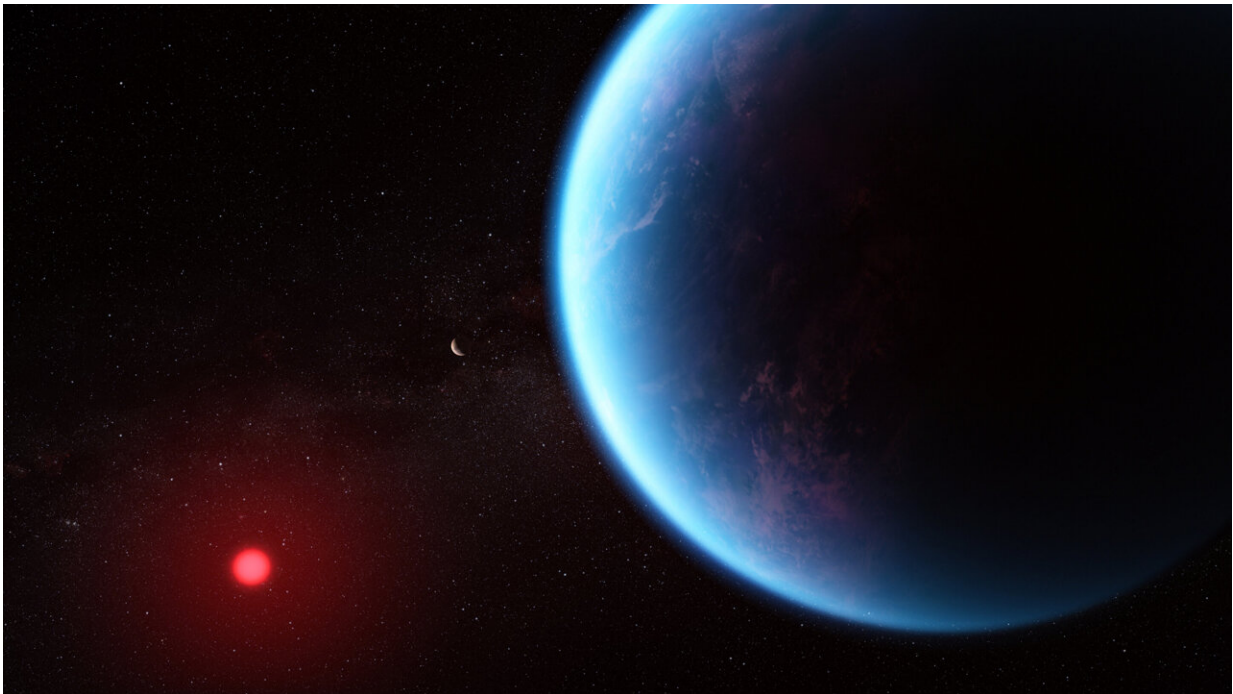


# Webb discovers methane, carbon dioxide in atmosphere of K2-18 b

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This illustration shows what exoplanet K2-18 b could look like based on science data. K2-18 b, an exoplanet 8.6 times as massive as Earth, orbits the cool dwarf star K2-18 in the habitable zone and lies 120 light years from Earth. A new investigation with NASA's James Webb Space Telescope into K2-18 b, an exoplanet 8.6 times as massive as Earth, has revealed the presence of carbon-bearing molecules including methane and carbon dioxide. The abundance of methane and carbon dioxide, and shortage of ammonia, support the hypothesis that there may be a water ocean underneath a hydrogen-rich atmosphere in K2-18 b. In this illustration, the exoplanet K2-18 c is shown between K2-18 b and its star. Credit: Illustration: NASA, ESA, CSA, Joseph Olmsted (STScI); Science: Nikku Madhusudhan (IoA)

Carbon-bearing molecules have been discovered in the atmosphere of the habitable zone exoplanet K2-18 b by an international team of astronomers using data from the NASA's James Webb Space Telescope. These results are consistent with an exoplanet that may contain ocean-covered surface underneath a hydrogen-rich atmosphere. This discovery provides a fascinating glimpse into a planet unlike anything else in our solar system, and raises interesting prospects about potentially habitable worlds elsewhere in the universe.

A new investigation with NASA's James Webb Space Telescope into K2-18 b, an [exoplanet](#) 8.6 times as massive as Earth, has revealed the presence of carbon-bearing molecules including methane and carbon dioxide. Webb's discovery adds to recent studies suggesting that K2-18 b could be a Hycean exoplanet, one which has the potential to possess a hydrogen-rich atmosphere and a water ocean-covered surface.

The first insight into the atmospheric properties of this [habitable-zone](#) exoplanet came from observations with NASA's Hubble Space Telescope, which prompted further studies that have since changed our understanding of the system.

K2-18 b orbits the cool dwarf star K2-18 in the habitable zone and lies 120 light-years from Earth in the constellation Leo. Exoplanets such as K2-18 b, which have sizes between those of Earth and Neptune, are unlike anything in our solar system. This lack of equivalent nearby [planets](#) means that these 'sub-Neptunes' are poorly understood, and the nature of their atmospheres is a matter of active debate among astronomers.

The suggestion that the sub-Neptune K2-18 b could be a Hycean exoplanet is intriguing, as some astronomers believe that these worlds

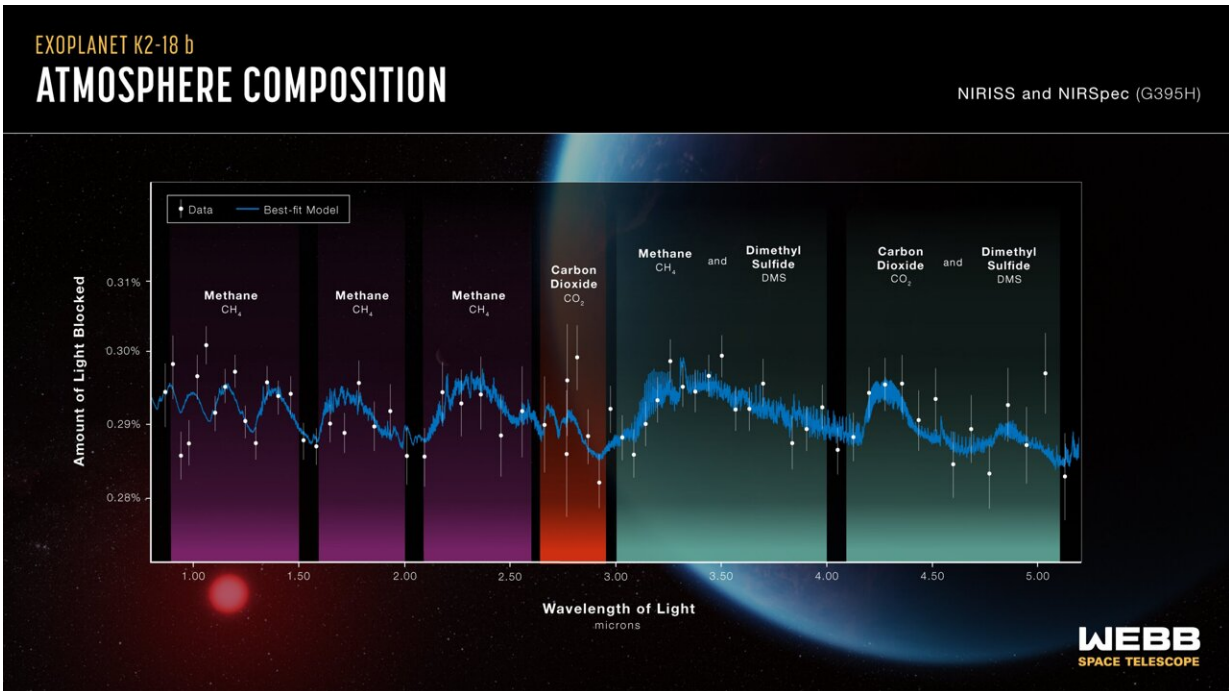
are promising environments to search for evidence for life on exoplanets.

"Our findings underscore the importance of considering diverse habitable environments in the search for life elsewhere," explained Nikku Madhusudhan, an astronomer at the University of Cambridge and lead author of the paper announcing these results. "Traditionally, the search for life on exoplanets has focused primarily on smaller rocky planets, but the larger Hycean worlds are significantly more conducive to atmospheric observations."

The abundance of methane and carbon dioxide, and shortage of ammonia, support the hypothesis that there may be a water ocean underneath a hydrogen-rich atmosphere in K2-18 b. These initial Webb observations also provided a possible detection of a molecule called dimethyl sulfide (DMS). On Earth, this is only produced by life. The bulk of the DMS in Earth's atmosphere is emitted from phytoplankton in marine environments.

The inference of DMS is less robust and requires further validation.

"Upcoming Webb observations should be able to confirm if DMS is indeed present in the atmosphere of K2-18 b at significant levels," explained Madhusudhan.



Spectra of K2-18 b, obtained with Webb’s NIRISS (Near-Infrared Imager and Slitless Spectrograph) and NIRSpec (Near-Infrared Spectrograph) displays an abundance of methane and carbon dioxide in the exoplanet’s atmosphere, as well as a possible detection of a molecule called dimethyl sulfide (DMS). The detection of methane and carbon dioxide, and shortage of ammonia, are consistent with the presence of an ocean underneath a hydrogen-rich atmosphere in K2-18 b. K2-18 b, 8.6 times as massive as Earth, orbits the cool dwarf star K2-18 in the habitable zone and lies 110 light years from Earth. Credit: Illustration: NASA, ESA, CSA, Ralf Crawford (STScI), Joseph Olmsted (STScI); Science: Nikku Madhusudhan (IoA)

While K2-18 b lies in the habitable zone, and is now known to harbor carbon-bearing molecules, this does not necessarily mean that the planet can support life. The planet's large size—with a radius 2.6 times the radius of Earth—means that the planet's interior likely contains a large mantle of high-pressure ice, like Neptune, but with a thinner hydrogen-rich atmosphere and an ocean surface. Hycean worlds are predicted to

have oceans of water. However, it is also possible that the ocean is too hot to be habitable or be liquid.

"Although this kind of planet does not exist in our solar system, sub-Neptunes are the most common type of planet known so far in the galaxy," explained team member Subhajit Sarkar of Cardiff University. "We have obtained the most detailed spectrum of a habitable-zone sub-Neptune to date, and this allowed us to work out the molecules that exist in its atmosphere."

Characterizing the atmospheres of exoplanets like K2-18 b—meaning identifying their gases and physical conditions—is a very active area in astronomy. However, these planets are outshone—literally—by the glare of their much larger parent stars, which makes exploring exoplanet atmospheres particularly challenging.

The team sidestepped this challenge by analyzing light from K2-18 b's parent star as it passed through the exoplanet's atmosphere. K2-18 b is a transiting exoplanet, meaning that we can detect a drop in brightness as it passes across the face of its host star. This is how the exoplanet was first discovered in 2015 with NASA's K2 mission. This means that during transits a tiny fraction of starlight will pass through the exoplanet's atmosphere before reaching telescopes like Webb. The starlight's passage through the exoplanet atmosphere leaves traces that astronomers can piece together to determine the gases of the exoplanet's [atmosphere](#).

"This result was only possible because of the extended wavelength range and unprecedented sensitivity of Webb, which enabled robust detection of spectral features with just two transits," said Madhusudhan. "For comparison, one transit observation with Webb provided comparable precision to eight observations with Hubble conducted over a few years and in a relatively narrow wavelength range."

"These results are the product of just two observations of K2-18 b, with many more on the way," explained team member Savvas Constantinou of the University of Cambridge. "This means our work here is but an early demonstration of what Webb can observe in habitable-zone exoplanets."

The team's results [were accepted](#) for publication in *The Astrophysical Journal Letters*.

The team now intends to conduct follow-up research with the telescope's MIRI (Mid-Infrared Instrument) spectrograph that they hope will further validate their findings and provide new insights into the environmental conditions on K2-18 b.

"Our ultimate goal is the identification of life on a habitable exoplanet, which would transform our understanding of our place in the universe," concluded Madhusudhan. "Our findings are a promising step towards a deeper understanding of Hycean worlds in this quest."

**More information:** Carbon-bearing Molecules in a Possible Hycean Atmosphere, *Astrophysical Journal Letters* (2023).

[esawebb.org/media/archives/rel...ic2321/weic2321a.pdf](https://esawebb.org/media/archives/rel...ic2321/weic2321a.pdf)

Provided by NASA

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