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CUTTING EDGE

Solar heating has puffed up WASP-39b to be larger than Jupiter

JWST reveals active exoplanet atmospheres

The telescope has found evidence of atmospheric reactions above an exoplanet

The James Webb Space Telescope (JWST) has been fully calibrated and operational for over six months now. The incredible images it has returned, rich with eye-popping detail, tend to make the news, but the JWST has also made a number of pivotal contributions to our understanding of the cosmos.

As part of the first round of science observation programmes, JWST has been observing transiting exoplanets. This programme was proposed and led by three principal investigators: Natalie Batalha at the NASA Ames Research Center, Jacob Bean at the University of Chicago, and Kevin Stevenson at the Space Telescope Science Institute. But the particular research paper I'm reporting on here involved some 80-odd co-authors – it represents a phenomenal collaborative effort of planetary scientists.

JWST was used to observe WASP-39b, an exoplanet orbiting a star around 700 lightyears away. It has roughly the mass of Saturn, is 30% larger than Jupiter, and orbits its Sun-like star eight times closer than Mercury is to our Sun. The team collected data across a broad range of the near-infrared spectrum while the planet was transiting in front of its star, and by analysing the absorption features were able to explore the make-up of the planet's atmosphere.

The team detected atmospheric constituents, including sodium, potassium, carbon dioxide and water vapour, which have all previously been found. But they also detected sulphur dioxide, a first for an exoplanet atmosphere. Sulphur dioxide is released by volcanism on terrestrial worlds – such as Earth, Venus and Jupiter's moon Io – but in gas giants like WASP-39b it must come from a different source.

In our local gas giants, sulphur deep in the atmosphere exists as hydrogen sulphide gas, but as this is churned up to higher altitudes the energetic photons of ultraviolet rays from the Sun break apart the hydrogen sulphide and drive further chemical reactions to produce sulphur dioxide. Such UV-driven reactions are known as photochemistry, and in Earth's atmosphere, for example, produce the ozone layer by driving reactions of oxygen molecules. This data on WASP-39b is the first concrete indication of photochemistry being crucial in the atmospheric composition of exoplanets too.

"The team detected sodium, potassium, carbon dioxide and water vapour. But also sulphur dioxide, a first for an exoplanet"

The presence of sulphur dioxide at the signal level discovered by the team also has other implications. A fundamental measure of the composition of gas giant planets is their 'metallicity' – that is, how rich they are in elements heavier than helium. These results indicate WASP-39b must have a metallicity around 10 times that of the Sun, so similar measurements of other exoplanet atmospheres can be used as a powerful tracer for heavy elements in general.

As well as marking an important first for exoplanet research – the detection of photochemical products such as sulphur dioxide – these results demonstrate just how capable this new observatory is for characterising exoplanets compared to previous space telescopes such as Hubble and Spitzer. And this bodes well for JWST's ability to probe the atmospheres of smaller, rocky planets, such as those in the TRAPPIST-1 system.

Prof Lewis Dartnell is an astrobiologist at the University of Westminster

Lewis Dartnell was reading... *Direct Evidence of Photochemistry in an Exoplanet Atmosphere* by Shang-Min Tsai et al.
Read it online at: arxiv.org/abs/2211.10490

NASA/ESA/CSA/J. OLMSTED (STSCI), NASA/JPL-CALTECH/JUDY SCHMIDT

Expansion leads to increased tension

JWST observations seem to confirm cosmology's biggest conundrum

Prof Chris Lintott is an astrophysicist and co-presenter on *The Sky at Night*

Cosmologists like an argument, and one of the biggest surprises of the last decade has been the slow emergence of a disagreement between various methods of measuring the Hubble Constant, the speed of the Universe's expansion. Two camps exist. There are those who study the cosmic microwave background, light emitted just 400,000 years after the Big Bang, and extrapolate forward to work out the Constant. They get consistently higher values than their rivals, who measure expansion directly by observing the present-day Universe. As each set of measurements has grown more accurate, this difference – euphemistically known as the 'Hubble tension' – has only increased.

JWST should help, especially with those local measurements which rely on studying Type Ia supernovae. These brilliant explosions shine with roughly the same peak luminosity wherever they occur. Knowing how bright they really are, we can work out their distance in the same way that you would judge the distance of a car by observing the brightness of its headlights when crossing the road at night. (This excellent analogy was shared with me by my colleague Becky Smethurst, and it works well – in fact, just as we could do a better job by knowing the make and model of each car, we can improve our Type Ia measurements by adjusting them according to how different types brighten and fade.)

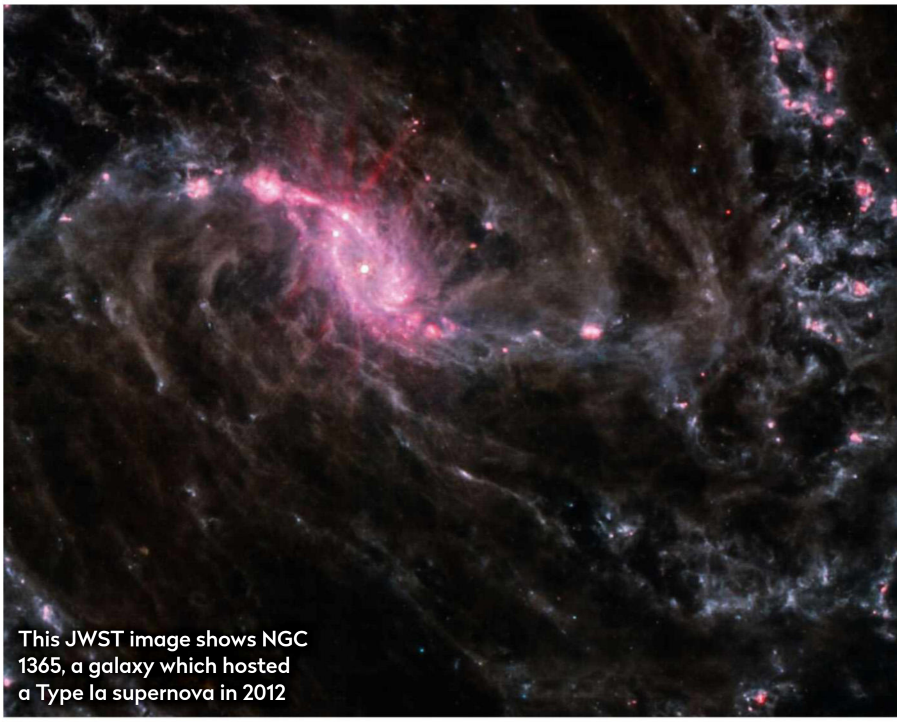
The supernova distance scale needs to be calibrated, though. Since Henrietta Leavitt in the early 20th century, astronomers have done this by spotting Cepheids, bright variable stars the speed of whose pulses reveals their luminosity and hence their distance. The Hubble Space Telescope is called Hubble because one of its original purposes was to observe more of these stars, and thus pin down the Hubble Constant once and for all.

"The Hubble Space Telescope is called Hubble because one of its original purposes was to pin down the Hubble Constant once and for all"

And yet there is still tension. One possibility is that Hubble may be systematically wrong in its measurements of Cepheids, with contamination from any red giants lurking in the background a particular worry. This sort of problem is worse in the infrared, a wavelength range often used because it is relatively unaffected by dust. While observations for the main JWST Cepheid programme have only just started, a short paper has given us a preview.

One of the nearby galaxies which has hosted a Type Ia supernova, NGC 1365, has already been snapped by JWST, as part of an effort to study its star formation, and this month's paper uses the data obtained for this purpose to check in on NGC 1365's Cepheids. The news is good for lovers of tension; these new results agree with the HST measurements, so there's no evidence of any systematic error that might bring the measurements together.

It is, though, just one galaxy. If these results are borne out by studies of many more, it'll be a boost for those cosmologists who hope that explaining the observed difference will lead us to new theories, and perhaps a new understanding of the cosmos. New results should turn up later this year; watch this space!



This JWST image shows NGC 1365, a galaxy which hosted a Type Ia supernova in 2012

Chris Lintott was reading… *A First Look at Cepheids in a SN Ia Host with JWST* by Wenlong Yuan et al. **Read it online at: arxiv.org/abs/2209.09101**