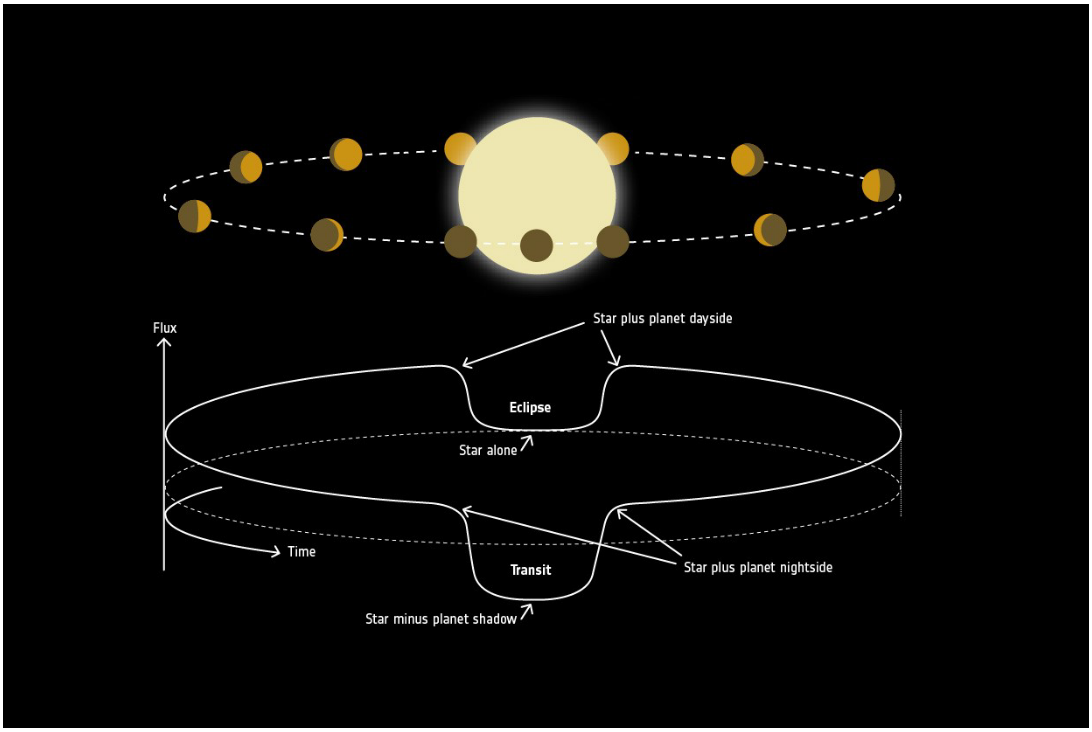
An exotic water cycle and metal clouds on a hot exoplanet WASP-121b

An international team of astronomers, led by Dr. Thomas Mikal-Evans from the Max Planck Institute for Astronomy (MPIA) in Germany and including Dr. Jayesh Goyal from the National Institute of Science Education and Research (NISER), Odisha in India have made the first detailed measurement of atmospheric nightside conditions of a tidally locked hot Jupiter. By including measurements from the dayside hemisphere, they determined how water changes physical states when moving between the hemispheres of the exoplanet WASP-121 b. While airborne metals and minerals evaporate on the hot dayside, the cooler night side features metal clouds and rain made of liquid gems. This study, published in *Nature Astronomy* (*https://www.nature.com/articles/s41550-021-01592-w*), is a big step in deciphering the global cycles of matter and energy in the atmospheres of exoplanets.

"*WASP-121b is an exoplanet located at a distance of 855 light-years from Earth. Measuring and understanding the atmospheric properties of exoplanets at such large distances is exciting, but also very difficult. Hence, this discovery of exotic water cycle on an exoplanet is a big step forward in our understanding of faraway worlds*" co-author Dr. Jayesh Goyal from NISER says. Dr. Mikal-Evans further points out "Despite the discovery of thousands of exoplanets, we've only been able to study the atmospheres of a small fraction due to the challenging nature of the observations".



This image illustrates how a star illuminates and heats the dayside hemisphere of an orbiting, tidally locked planet. Similar to how we see Venus in the Solar System, such a planet shows different fractions of its day and night sides during one orbit, the phases. By observing WASP-121 b, the astronomers have monitored the planetary signal depending on the degree of illumination. The planet's dayside hemisphere spectrum was obtained just before it disappeared behind the star. Similarly, the nightside spectrum corresponds to an orbital phase right before passing in front of the star.
Image: ESA (https://www.esa.int/ESA_Multimedia/Images/2019/12/Exoplanet_phase_curve)

The exotic water cycle on WASP-121 b

On Earth, water constantly changes its physical state. Solid ice melts into liquid water. Water evaporates into a gas and then condenses into droplets to form clouds. The cycle closes when those droplets grow to raindrops that eventually fall down to fill rivers and oceans. However, we find that the water cycle on WASP-121 b looks completely different.

On the side of the planet facing the central star, the upper atmosphere becomes as hot as about 3000 degrees Celsius. At such temperatures, the water begins to glow, and many of the molecules even break down into their atomic components. The Hubble data also reveal that the temperature drops by approximately 1500 degrees Celsius on the nightside hemisphere. This extreme temperature difference between the two hemispheres gives rise to strong winds that sweep around the entire planet from west to east, dragging the disrupted water molecules along. Eventually, they reach the nightside. The lower temperatures allow the hydrogen and oxygen atoms to recombine, forming water vapour again before being blown back around to the dayside and the cycle repeats. Temperatures never drop low enough for water clouds to form throughout the cycle, let alone rain. Instead of water, clouds on WASP-121b mainly consist of metals such as iron, magnesium, chromium and vanadium.

WASP-121b will be again observed using the recently launched James Webb Space Telescope (JWST), the largest space telescope ever built, which can potentially reveal much more information about this exotic exoplanet.

Additional information

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