



P.L.RAJ IAS & IPS ACADEMY

Building Bureaucrats Since 2006

2. JWST Maps Daily Weather Cycle on Exoplanet Wasp-94a B – Science & Technology

NASA's James Webb Space Telescope (JWST) has mapped a daily weather cycle on an exoplanet nearly 700 light-years away, marking the first time a repeating daily cloud cycle has been observed on an alien world. The planet, WASP-94A b, is a Hot Jupiter located in the constellation Microscopium. Unlike Earth's water vapor clouds, the clouds on this planet are made of magnesium silicate (vaporized rock), iron, and magnesium sulphide. JWST detected stronger water vapor signals from the planet's relatively clear evening limb, suggesting a Jupiter-like atmospheric composition previously unrecognized. The discovery represents a landmark achievement in exoplanet atmospheric science.

1. Recent Key Findings

Atmospheric Asymmetry

1. JWST observed planet's terminator region (boundary between day and night sides)
2. **Morning limb** - Cloud-rich
3. **Evening limb** - Comparatively clearer
4. Asymmetry revealing distinct atmospheric dynamics

Clouds of Vaporized Rock

1. Unlike Earth (water vapor clouds), WASP-94A b clouds made of -
 1. Magnesium silicate (vaporized rock)
 2. Iron
 3. Magnesium sulphide
2. Extreme temperature conditions creating exotic cloud compositions

Daily Weather Cycle

1. **Nightside** - Rock-forming minerals cool down, condense into clouds
2. **Atmospheric winds** - Powerful winds push clouds from nightside to dayside
3. **Dayside** - Extreme heat ($>1,000^{\circ}\text{C}$) causes mineral clouds to evaporate or move into deeper atmospheric layers
4. **Evening limb** - Left relatively clear after cloud evaporation
5. First observed repeating daily cycle on alien world

Overcoming Cloud Obstruction

1. Pervasive clouds usually block telescope's view like frosted pane of glass distorting data
2. By observing relatively clear evening limb, JWST detected -
 1. Stronger water vapor signals
 2. Suggesting planet's atmosphere chemically closer to Jupiter-like composition than earlier understood
3. Breakthrough in exoplanet atmospheric characterization

2. About WASP-94A b (The Exoplanet)

Classification

1. "Hot Jupiter" - Massive gas giant located in constellation Microscopium
2. Named for star WASP-94A it orbits

Physical Traits

1. Almost twice as big as Jupiter in volume
2. Only half Jupiter's mass (lower density than Jupiter)
3. Gas giant composition

Orbit

1. Orbits extremely close to its star
2. Takes just four Earth days to complete one full year (extremely short orbital period)
3. Proximity to star creates extreme temperatures

Tidal Locking

1. Due to tidal locking, same side of WASP-94A b always faces its star
2. Creates - Permanent scorching dayside ($>1,000^{\circ}\text{C}$) and relatively cooler nightside
3. Similar to Moon's tidal locking with Earth (same face always visible)

3. About Exoplanets

Definition

1. Any planet orbiting a star outside our Solar System
2. More than 6,000 found so far (confirmed by NASA)

Diverse Environments

Extreme weather conditions -

1. Rain made of molten metal
2. Vaporized rock precipitation
3. Liquid glass driven by supersonic winds
4. Diamonds raining down (high-pressure carbon atmospheres)

Key Detection Methods

1. **Transit Method** - Tracking slight dimming of star's light when exoplanet passes directly in front; measures planet size relative to star
2. **Transmission Spectroscopy** - As starlight filters through edges of planet's atmosphere during transit, gases selectively absorb specific wavelengths; reading missing wavelengths identifies exact atmospheric chemicals

Significance

1. Understanding how planetary systems form, grow, differ from our Solar System
2. Searching for potentially habitable worlds
3. Advancing atmospheric science beyond Solar System

4. About James Webb Space Telescope (JWST)

Overview

1. NASA's premier space observatory launched December 25, 2021
2. Observes in infrared wavelengths (invisible to human eye; penetrates dust clouds)
3. Located at Lagrange Point 2 (L2) approximately 1.5 million km from Earth
4. Collaborative project - NASA, European Space Agency (ESA), Canadian Space Agency (CSA)

Capabilities

1. Primary mirror - 6.5 meters (gold-coated beryllium segments)
2. Infrared sensitivity enabling - Deep universe observations, exoplanet atmosphere analysis, star formation studies
3. Succeeds Hubble Space Telescope (visible/ultraviolet light)

Achievements

1. Deepest infrared image of early universe

2. Atmospheric characterization of multiple exoplanets
3. Detection of CO₂ in exoplanet atmospheres
4. Observation of stellar nurseries, galaxy formation

5. Significance of Discovery

Scientific Significance

1. First repeating daily weather cycle observed on alien world
2. Demonstrates JWST's capability to study atmospheric dynamics beyond detection
3. New understanding of Hot Jupiter atmospheric processes
4. Water vapor detection indicating complex atmospheric chemistry

Broader Implications

1. Understanding atmospheric evolution of gas giants
2. Improved models for exoplanet weather, climate
3. Potential insights into early Solar System's gas giant formation
4. Advancing search for biosignatures in exoplanet atmospheres

6. Conclusion

JWST's mapping of daily weather cycle on WASP-94A b (Hot Jupiter, 700 light-years, constellation Microscopium) marks historic first—repeating alien weather pattern observed through atmospheric asymmetry between cloud-rich morning limb and clearer evening limb. Exotic clouds of magnesium silicate-iron-magnesium sulphide (vaporized rock) form on cooler nightside, transported by atmospheric winds to scorching dayside (>1,000°C) where they evaporate, leaving evening limb clear. This asymmetry enabled JWST to detect stronger water vapor signals through transmission spectroscopy revealing Jupiter-like atmospheric composition. WASP-94A b's tidal locking (same face permanently toward star), four-day orbital period, twice Jupiter's volume but half its mass created conditions supporting this exotic weather cycle. Discovery advances exoplanet atmospheric science, planetary formation understanding, and JWST's transformative capabilities in characterizing alien worlds beyond simple detection toward dynamic weather monitoring.

Source - <https://economictimes.indiatimes.com/news/international/us/on-this-planet-clouds-emerge-every-morning-and-disappear-by-night-james-webb-space-telescope-reveals-daily-cloud-cycle-on-wasp-94a-b/articleshow/131471160.cms?from=mdr>