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Keck Telescope images of Uranus reveal ring, atmospheric fireworks

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Louisville, Ky. — As summer draws to a close in the southern hemisphere of Uranus, storm clouds are brewing in the upper atmosphere, northern hemisphere winds are gusting to 250 miles per hour, and the planet's rings are getting brighter every day.

This weather report comes from researchers using the Keck II 10-meter telescope atop Mauna Kea volcano in Hawaii, where recent observations are proving that Uranus is not the "boring and unchanging" planet people have assumed, according to Imke de Pater, professor of astronomy at the University of California, Berkeley. The new images were obtained with the second-generation Near Infrared Camera (NIRC2) using the adaptive optics system on the Keck II telescope.

"It's really intriguing, the planet seems to be getting more active as the equinox approaches," said de Pater, who, with colleague Heidi B. Hammel of the Space Science Institute in Boulder, Colo., has been observing Uranus since 2000 with adaptive optics on the Keck II telescope.

"When the Voyager 2 spacecraft flew by Uranus in 1986, it saw almost no discrete cloud activity – you could literally count the number of discrete clouds on your fingers: 10! Most astronomers decided that Uranus was a boring, static planet," Hammel added. "What we are seeing now is the opposite, that actually there are changes, and they are visible to Keck and the Hubble Space Telescope."

The team also spotted an inner ring, the 11th, that was seen only once before – in a single image taken by Voyager. Really a sheet of rocky debris, the ring – called 1986U2R – is the innermost of the 11, calculated by the team to be about 3500 kilometers (2,200 miles) wide and centered about 39,600 kilometers (24,600 miles) from the planet core. Though a thousand times dimmer than the brightest ring – the epsilon ring – the inner ring is now visible because it is nearly edge-on to the sun and Earth, and so reflects more light back to Earth observers. The team also found that the nine main rings of Uranus consist of a single layer of particles, a so-called monolayer, never before seen in other rings.

De Pater, Hammel and colleague Seran Gibbard of Lawrence Livermore National Laboratory report their observations this week at the American Astronomical Society's Division for Planetary Sciences meeting, which is being held Nov. 8-12 in Louisville, Ky. De Pater and Hammel also will discuss their findings at a media briefing on Nov. 10 at 12 noon.

Additional members of the atmospheric team are Wes Lockwood of Lowell Observatory in Flagstaff, Ariz., and Kathy Rages of the SETI Institute in Mountain View, Calif.

The Voyager 2 spacecraft made the first close-up observations of Uranus when it flew by the planet 18 years ago. At that time, the planet was at the peak of its southern summer, with the entire southern hemisphere bathed in continuous sunlight. The spacecraft observed faint, low-altitude bands around the planet, a faint echo of the colorful bands on Jupiter and Saturn, plus just 10 discrete clouds in the sunlit southern hemisphere compared with Jupiter’s thousands and Saturn’s hundreds. The relatively static atmosphere led some astronomers to label Uranus a dull and uninteresting planet, theorizing that the thick haze covering the planet’s southern hemisphere somehow set up a stratified atmosphere that inhibited convection.

The bands and clouds are thought to be made of crystals of methane condensing in the planet's atmosphere, which is mostly hydrogen and helium. Astronomers predict that the atmosphere surrounds a core of rock, surrounded by water, ammonia and methane slush. The Voyager spacecraft also measured the length of the Uranian day – 17 hours, 14 minutes in Earth time – based on the rotation of the planet's magnetic field.

Starting in 1994, observations by the Hubble Space Telescope and later by Keck have shown that the banded structure near the southern pole has been evolving very slowly. Also, in the northern hemisphere, bright high-altitude clouds have been popping up ever since sunlight started to reach north of the equator.

Now, for the first time, de Pater, Hammel and Gibbard have observed high-altitude cloud activity in the planet's southern hemisphere, indicating "vigorous convection" in the atmosphere. Convection – the turbulent upward and downward movement of large masses of air – creates clouds on Uranus just as it does on Earth.

"One of several large clouds in the southern hemisphere surprised us by showing a very bright core. This bright core was also visible at a wavelength of 2.2 microns, which normally shows a very dark planet due to absorption by methane," said de Pater. "We have never seen such vigorous convective activity in the southern hemisphere before. We think this might be a response to the changing geometry, because this region of Uranus now experiences both day and night, whereas during the Voyager flyby it was always in sunlight."

Hammel referred to the bright cloud feature as "Fourth of July fireworks," because they first surprised the team on July 4 and then faded below detectable levels by the 9th of July. Other astronomers could not detect the feature when looking at Uranus a few days later.

"Thus, this is the first time southern features have penetrated upward high enough to be detected at these wavelengths," Hammel explained. "Clouds are not unprecedented in this hemisphere, but penetration of these clouds' activity to higher altitudes is unprecedented."

The beginning of autumn in the planet's southern hemisphere and the arrival of spring in the north is a sight never before seen with high-resolution telescopes like the Keck, since it occurs only once every 84 Earth years as the planet trundles around the Sun. As the 2007 equinox draws closer, churning activity is starting at high altitudes in the southern hemisphere.

"The amount of sunlight hitting different parts of the planet is changing as Uranus moves around the Sun and presents different faces to the Sun," Hammel said. "So, the changing radiation pattern the clouds are experiencing is changing the heat balance in the atmosphere. This could be causing convection, or it could be turning off processes that had been inhibiting it."

Uranus has extreme seasons because its rotational axis is tilted about 90 degrees from the plane of its orbit – that is, its rotational axis lies nearly in the plane of its orbit.

“In 1986, the southern half of the planet was pointing almost directly at the Sun, just sitting there baking in the sunlight, and the northern half of the planet was just radiating heat into the blackness of space,” Hammel said. “Now, the southern part that had been getting huge amounts of sunlight is experiencing increasing darkness every Uranian night.”

The northern hemisphere of Uranus, on the other hand, is getting more and more sunlight, and by the year 2028, the planet’s north pole will point directly at the Sun, a complete reversal of the situation when Voyager flew by.

“We're seeing more of the north as the planet rotates into view, and we are measuring the northernmost features we've ever seen on Uranus,” Hammel said. She expects soon to see a bright collar develop around the north pole, similar to the collar that so far has been a constant feature around the south pole. “But who knows?” Hammel pointed out. “Maybe that southern collar will dissipate first. It’s fun to speculate, and even more fun to watch.”

Other new observations reported by Hammel, de Pater and Gibbard include the fastest winds ever recorded on Uranus. The winds, between 107 and 111 meters per second (240 and 260 miles per hour), were measured in October 2003 on the northernmost parts of the planet visible at that time.

“At least as interesting as Uranus' atmosphere is its ring system,” said de Pater. “The rings are slowly closing up while approaching the 2007 equinox, so we are starting to see faint sheets of dust like the innermost Uranian ring, called 1986U2R, that had been seen only once before."

The team has been able to extract much more information on this ring, including its brightness and radial extent, than had been possible from the single Voyager image that first revealed it.

Perhaps most surprising is the team's discovery that in Uranus' main rings, the ring "particles," which were deduced to be large boulders from Voyager data, are distributed within a single layer.

"We had never seen such an odd configuration in other ring systems," said de Pater. "Rings in other systems, like Saturn's rings, are usually depicted as being many particles thick. Uranus' ring system is unique in this respect."

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The W.M. Keck Observatory is operated by the California Association for Research in Astronomy, a scientific partnership of the California Institute of Technology, the University of California and NASA. The Space Science Institute is a nonprofit organization with the unique mission to integrate world-class scientific research with education and public outreach. The institute's research program includes earth science, space physics, planetary science and astrophysics.

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VISUALS: Images of Uranus and its rings can be viewed and downloaded from an embargoed Web site, **http://astron.berkeley.edu/~newstar/Infrared/UranusAo/pressrelease2004.htm**.