The lower atmosphere of Pluto revealed

March 2 2009

Artist's impression of how the surface of Pluto might look, according to one of the two models that a team of astronomers has developed to account for the observed properties of Pluto's atmosphere, as studied with CRIRES. The image shows patches of pure methane on the surface. At the distance of Pluto, the Sun appears about 1,000 times fainter than on Earth. Credit: ESO/L. Calçada

(PhysOrg.com) -- "With lots of methane in the atmosphere, it becomes clear why Pluto's atmosphere is so warm," says Emmanuel Lellouch, lead author of the paper reporting the results.

Pluto, which is about a fifth the size of Earth, is composed primarily of rock and ice. As it is about 40 times further from the Sun than the Earth on average, it is a very cold world with a surface temperature of about minus 220 degrees Celsius!

It has been known since the 1980s that Pluto also has a tenuous atmosphere [1], which consists of a thin envelope of mostly nitrogen,

with traces of methane and probably carbon monoxide. As Pluto moves away from the Sun, during its 248 year-long orbit, its atmosphere gradually freezes and falls to the ground. In periods when it is closer to the Sun — as it is now — the temperature of Pluto's solid surface increases, causing the ice to sublimate into gas.

Until recently, only the upper parts of the atmosphere of Pluto could be studied. By observing stellar occultations, a phenomenon that occurs when a Solar System body blocks the light from a background star, astronomers were able to demonstrate that Pluto's upper atmosphere was some 50 degrees warmer than the surface, or minus 170 degrees Celsius. These observations couldn't shed any light on the atmospheric temperature and pressure near Pluto's surface. But unique, new observations made with the CRyogenic InfraRed Echelle Spectrograph (CRIRES), attached to ESO's Very Large Telescope, have now revealed that the atmosphere as a whole, not just the upper atmosphere, has a mean temperature of minus 180 degrees Celsius, and so it is indeed "much hotter" than the surface.

In contrast to the Earth's atmosphere [2], most, if not all, of Pluto's atmosphere is thus undergoing a temperature inversion: the temperature is higher, the higher in the atmosphere you look. The change is about 3 to 15 degrees per kilometre. On Earth, under normal circumstances, the temperature decreases through the atmosphere by about 6 degrees per kilometre.

"It is fascinating to think that with CRIRES we are able to precisely measure traces of a gas in an atmosphere 100 000 times more tenuous than the Earth's, on an object five times smaller than our planet and located at the edge of the Solar System," says co-author Hans-Ulrich Käufl. "The combination of CRIRES and the VLT is almost like having an advanced atmospheric research satellite orbiting Pluto."

The reason why Pluto's surface is so cold is linked to the existence of Pluto's atmosphere, and is due to the sublimation of the surface ice; much like sweat cools the body as it evaporates from the surface of the skin, this sublimation has a cooling effect on the surface of Pluto. In this respect, Pluto shares some properties with comets, whose coma and tails arise from sublimating ice as they approach the Sun.

The CRIRES observations also indicate that methane is the second most common gas in Pluto's atmosphere, representing half a percent of the molecules. "We were able to show that these quantities of methane play a crucial role in the heating processes in the atmosphere and can explain the elevated atmospheric temperature," says Lellouch.

Two different models can explain the properties of Pluto's atmosphere. In the first, the astronomers assume that Pluto's surface is covered with a thin layer of methane, which will inhibit the sublimation of the nitrogen frost. The second scenario invokes the existence of pure methane patches on the surface.

"Discriminating between the two will require further study of Pluto as it moves away from the Sun," says Lellouch. "And of course, NASA's New Horizons space probe will also provide us with more clues when it reaches the dwarf planet in 2015."

Notes

[1] The atmospheric pressure on Pluto is only about one hundred thousandth of that on Earth, or about 0.015 millibars.

[2] Usually, air near the surface of the Earth is warmer than the air above it, largely because the atmosphere is heated from below as solar radiation warms the Earth's surface, which, in turn, warms the layer of the atmosphere directly above it. Under certain conditions, this situation

is inverted so that the air is colder near the surface of the Earth. Meteorologists call this an inversion layer, and it can cause smog build-up.

More information

E. Lellouch et al. 2009, A&A, in press, Pluto's lower atmosphere structure and methane abundance from high-resolution spectroscopy and stellar occultations. The team is composed of E. Lellouch, B. Sicardy, and C. de Bergh (Observatoire de Paris, France), H.-U. Käufl (ESO), S. Kassi and A. Campargue (Université Joseph Fourier, France).

Source: ESO