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Large Changes in Pluto's Atmosphere Revealed by Stellar Occultations

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Abstract. Pluto's tenuous nitrogen atmosphere was detected by stellar occultations in 1985 and 1988. This atmosphere is poorly known, however, due to the rarity of these events. We report here the first Pluto occultations observed since 1988, on 20 July and 21 August 2002. Our analysis reveals drastic changes undergone by the atmosphere since 1988, namely a two-fold pressure increase, the probable effect of seasonal changes on Pluto over this fourteen year interval.

1. Pluto's atmosphere

As Pluto is presently receding from the Sun, the amount of solar energy that reaches its surface decreases, so its surface is expected to cool. Surprisingly, however, we show that Pluto's atmosphere is expanding, rather than contracting. We present here a short summary of our results, which are presented in more details by Sicardy *et al.* (2003).

So far, the only way to study Pluto's atmosphere is to wait for a so-called "stellar occultation", when the refraction by the planet atmosphere causes a gradual dimming of the starlight. The previous occultation observed by several teams in 1988 revealed Pluto's tenuous nitrogen atmosphere, whose deepest layers reach pressures of a few microbars (Yelle & Elliot, 1997). This pressure is maintained by thermodynamical equilibrium between the nitrogen ice on the surface, at temperatures of 40-60 K, and the nitrogen vapor above it.

2. Observations and results

The first Pluto occultation successfully observed since 1988 occurred on 20 July 2002, during a campaign in South America organized by a group of Paris Observatory. The star dubbed "P126" went behind the planet as observed from an area ranging from Chile, Brazil, Peru, Bolivia and Ecuador. A successful observation was made by one of our teams near Arica, in northern Chile, using a 30-cm portable telescope and a CCD camera with no filter. One month later, on 21 August 2002, another occultation (of the star "P131.1") was successfully observed with the Canada-France-Hawaii 3.6-m Telescope (CFHT), yielding high quality data in the I band (0.89 μm).

Analysis of the data reveals that the pressure in Pluto's atmosphere more than doubled between 1988 (Yelle & Elliot, 1997) and 2002 (Elliot *et al*, 2003, Sicardy *et al.*, 2003). For instance, the pressure p at the distance $r=$ 1215 km from the planet center increased by a factor 2.1 between the two dates: $p = 5.0 \pm 0.6$ μbar in 2002, while $p = 2.33 \pm 0.24$ μbar in 1988.

One might naively expect an overall collapse of the atmosphere as the planet moves farther from the Sun and cools down. Seasonal variations, however, can overcome this tendency and explain the present expansion. Hansen & Paige (1996) show that there would be a period in Pluto's orbit - shortly after perihelion - when the south polar cap of the planet comes into sunlight after spending more than 120 years in darkness. This happened in 1987, and the sublimation of the solid nitrogen accumulated in this region would then feed the atmosphere, while it would take some time for the north polar cap, in darkness since 1987, to re-condense this excess of gas. Hansen and Paige (1996) predict that this expansion will last till 2015 or so, before the atmosphere shrinks again. More complications arise, however, as the albedo of the planet probably varies during the whole process, thus changing the surface temperature, and by the same way, the amount of nitrogen sublimated into the atmosphere.

Finally, some stellar scintillation is visible in the P131.1 light curve, thus revealing a dynamical activity in Pluto's atmosphere, maintained either by strong winds between the lit and dark hemispheres of the planet, or by convection near the surface.

References

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