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Triton's temperature profile and time evolution from the October 5th 2017 stellar occultation

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Abstract

On October 5th, 2017, over 80 sites in Europe, North Africa, and Eastern USA observed a stellar occultation by Triton. Around 25 of these were close enough to centrality to observe a central flash, the increase of brightness in the middle of the event. We will present our conclusions derived from this event, and compare them to the Voyager 2 observations in 1989, particularly the pressure obtained at prescribed levels, temperature, and any changes in the atmosphere's shape.

1. Introduction

Triton is the largest of Neptune's satellites with a radius of 1353 km. It is the only satellite, other than Titan, to possess a significant atmosphere. Its atmosphere (mainly composed of molecular nitrogen N_2) is special as it is in vapor pressure equilibrium with the N_2 frost at the surface. Seasonal effects on Triton are important due to the large variations of the sub-solar latitude, which implies that different terrains are illuminated as time changes (Fig. 1). Between 1990 and 2010, an "extreme solstice" occurred, where latitudes of up to 50º S were directly and constantly illuminated by the Sun. This occurs every 650 years, due to a combination of Neptune's heliocentric motion and Triton's orbital precession. Since 1989, with the Voyager 2 observations, combined with ground-based stellar occultations, an increase of pressure has been noted, by a factor of around two. This increase could stem from the sublimation of N_2 ice deposited on Triton's southern polar cap [1]. The stellar occultation of October 5th, 2017, was unique, as it was the first one favourable since 1997. It was visible from a large part of Europe and Northern Africa, as well as from eastern USA, resulting in a dense coverage of Triton's atmosphere (Fig. 2).

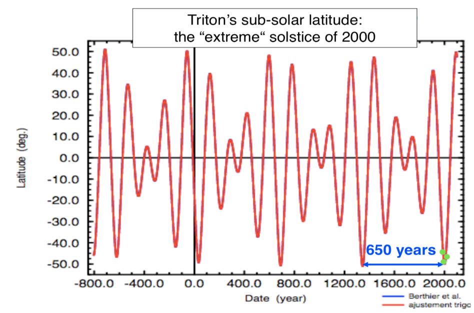

Figure 1 - Triton's subsolar latitude vs. time. Note the exceptional character of the 2000 solstice.

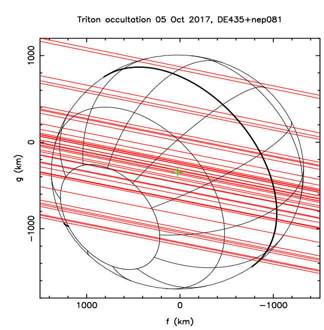

Figure 2 – Occultation chords for 40 stations across Triton's atmosphere. The green cross marks Triton's center.

2. Models

Refraction of stellar rays by the atmosphere causes a stellar flux drop, which provides Triton's atmospheric profiles (density, temperature, pressure, including p_{surf}) from altitudes of 10 km (~ 1 μbar) to about 100 km (0.1 μbar). Stations near centrality experienced the so-called central flash which constraints the sphericity of Triton's atmosphere and possible presence of hazes. One light curve (from the Liverpool telescope, in La Palma) was used to derive, through an inversion method, the pressure and temperature profiles, down to around 10 km above the surface (with the central flash layer lying at about 7 km above the surface).

3. Results

A temperature profile model was fitted to go to the surface (Fig. 3) and to explain all light curves. This results has a different shape from other models previously used, for instance, the model used in [2].

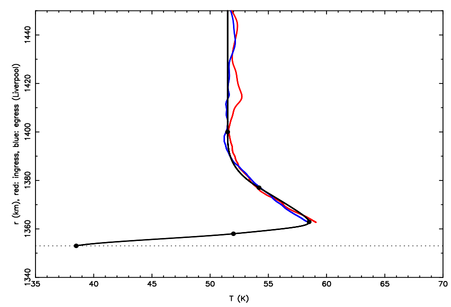

Figure 3 – Example of a temperature profile model in black. The red and blue curves are the temperature profile derived from the inversion of the Liverpool telescope light curve. Note the conspicuous negative temperature gradient at the bottom of the inverted profiles, and the steep inversion layer necessary to connect the inverted profiles to the surface, at ~ 38 K.

A direct comparison with our results and Voyager 2 data is possible, using the phase shift provided by [3] (Fig. 4). Our results imply only a slight change of atmospheric density, with a decrease of about 30% between 1989 and 2017 near the 10 km altitude level. These results will be discussed in the frame of a Global Climatic Model of Triton.

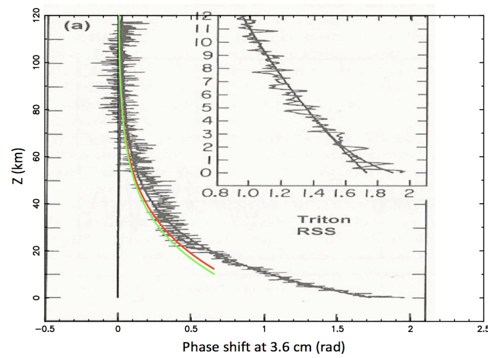

Figure 4 – The phase shift vs. altitude of the Voyager 2 radio signal, at 3.6 cm, caused by Triton's atmosphere in 1989, is plotted in black. The green and red profiles are the phase shifts caused by the inverted profile shown in Fig. 3 (occultation of October 5th, 2017), and represent the uncertainty domain of Triton's shadow center.

Acknowledgements

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