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Pluto's atmosphere structure from ground-based stellar occultations

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Abstract

Stellar occultations are a unique tool to study Pluto's atmosphere at pressure levels ranging from 10 μbar to about 0.1 μbar. Within those limits, they provide density, pressure and temperature profiles of the atmosphere. Here we report results obtained during campaigns that we organized to observe Pluto stellar occultations on 18 July 2012 and 04 May 2013. We will also report results from campaigns in 2015 (if successful), in particular the 29 june 2015 event in Australia and New Zealand, and the 26 July 2015 occultation in South America.

1. Introduction

The 18 July 2012 and 04 May 2013 stellar occultations by Pluto were among the best ever observed in terms of signal-to-noise ratios (SNR's) obtained and latitudinal coverage of the dwarf planet. The 2012 event was recorded from five different sites in South America, while the 2013 occultation was observed from six different sites, also in South America. Both occultations were recorded at the 8.2-m Very Large Telescope (VLT) of the European Southern Observatory using the NACO camera in H band. That instrument provided among the best SNR light-curves ever obtained during Pluto stellar occultations.

2. Results

Fig. 1 shows the temperature profiles retrieved from the inversions of the light-curves obtained in 2012 and 2013. In this diagram, the temperature T is plotted against r, the distance to Pluto's center. The profiles are obtained under the assumptions that Pluto's atmosphere is spherically symmetric and transparent (no hazes), see [1] for details.

Several features are noteworthy: (1) a strong positive temperature gradient at the bottom of the profiles, consistent with the presence of a stratosphere that connects the surface (temperature 40-55 K) to the upper atmosphere; (2) a distinctive temperature maximum of $T \approx 110$ K near r=1,220 km; and (3) a mesosphere with a negative temperature gradient of about -0.2 K km^{-1}. Possible origins of this negative gradient will be discussed, in particular the possible cooling role of species such as CO or HCN. The negative gradient could also be an apparent effect (i.e. the atmosphere could be isothermal) caused by unmodeled processes such as a partial differentiation of molecular nitrogen and neon, or the presence of zonal winds around $r = 1,250$ km. We will show that none of those explanations satisfactorily explains the observed mesospheric trend.

The inversions also provide pressure profiles for the two events, with values of 2.16 ± 0.02 μbar and $2.30 \pm$

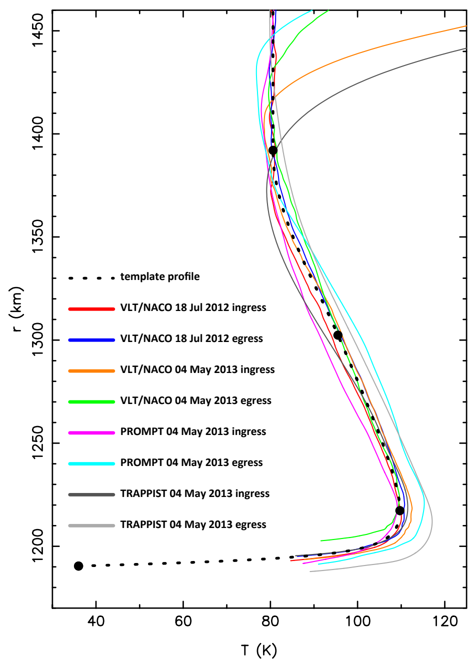

Figure 1: Pluto's atmospheric temperature profiles derived from the inversion of the light-curves obtained during the Pluto stellar occultations of 18 July 2012 and 04 May 2013. The radius r on the vertical axis is the distance to Pluto's center. The diverging behavior of the profiles observed at the top of the panel is caused by the increasing contribution of noise to the retrieved temperature profiles. The dotted line is a smooth atmospheric model that best fits our observed profiles.

0.01 μbar at $r = 1,275$ km for the 18 July 2012 and 04 may 2013 events, respectively. This is a small (6%) but significant (6-σ level) increase of pressure between the two dates, confirming with better accuracy the results of [2].

3. Future campaigns

At the moment of submission, we are planning campaigns to observe the 29 June 2015 Pluto occultation in Australia and New Zealand, as well as the 26 July 2015 event in South America.

The goal is to monitor Pluto's atmosphere two years after the events described above, and at the moment of the NASA *New Horizons* Pluto flyby of 14 July 2015. Preliminary results will be presented if good quality data are obtained during those campaigns.

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Based on observations made at ESO-Paranal with runs 089.C-0314(C) and 290.C-5084(B), using the VLT "Yepun" NACO camera.

References

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