Asteroids & Remote Planets Section

The Triton stellar occultation of 2017 October 05

On 2017 October 05 Triton, the largest satellite of Neptune, will occult a 12.7 V-mag star, visible from the US east coast, Northern Africa and Europe. This will be the first opportunity to monitor Triton's current atmospheric state and possible changes since the 1990s.

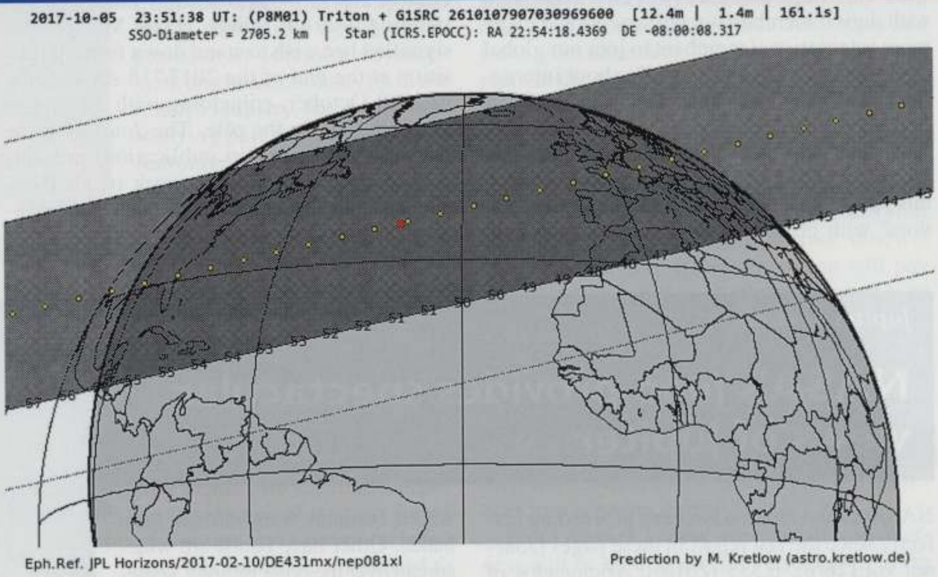

Figure 2. Prediction of the occultation by Triton on 2017 October 05 by the author using JPL's nep081xl+DE431mx ephemeris and *Gaia*'s DR1 star position. Later a *Gaia* DR2 pre-release star position became available, but the shift wrt to this DR1 release is marginal (some 10 km in cross-track direction and some seconds in time). The red dot marks the central occultation time (23:51:38 UT); the yellow dots correspond to the time ticks (seconds) on the southern shadow border.

Introduction

On 2017 October 05 Neptune's largest satellite Triton will occult the 12.7 V-mag star UCAC4 410-143659, as seen from the US east coast, Northern Africa, and Europe. After almost 10 years since the last documented Triton occultation (observed on 2008 May 21), this event will be a new opportunity to gather data about Triton's current atmospheric state and possible changes.

About Triton

Triton is the largest natural satellite of Neptune. It was discovered on 1846 October 10, by the English merchant and amateur astronomer William Lassell (1799–1880), just 17 days after the discovery of Neptune itself by the German astronomer Johann Gottfried Galle (1812–1910). The satellite is named after the Greek sea god Triton, the son of Poseidon. The name was proposed by Camille Flammarion in 1880, though until the discovery of the second moon Nereid in the year 1949, the name was not used and Triton was commonly referred just as 'the satellite of Neptune'.

With a diameter of 2700 km, Triton is the seventh-largest moon in the Solar System. Its mean density is 2.061g/cm^3. Triton orbits Neptune in a retrograde, almost perfect circular orbit with a sidereal period of about 5.9 days, at a mean distance of 354,760 km or 14.3 Neptune radii. In contrast to the Earth–Moon system the tidal interactions with this retrograde motion of Triton will cause it to spiral inward on a long-term scale. As soon as Triton falls inside Neptune's Roche limit this will result in a collision with Neptune and/or a tidal breakup of the satellite, forming a ring system similar to that around Saturn.

Because of its retrograde orbit (moons in retrograde orbits cannot form in the same region of the solar nebula as the planets they orbit), and its size and composition which is similar to Pluto, Triton is believed to be a dwarf planet captured by Neptune's gravity from the Kuiper Belt.

Similarly to Pluto, Triton has a thin nitrogen-dominated atmosphere, driven by surface ices, primarily N_2 and CH_4 frost. From stellar occultations[1] we know that Pluto's atmosphere has changed significantly due to seasonal effects (doubling of atmospheric pressure between 1988 and 2002). Pluto's orbit is much more elliptical than that of the other planets, and its rotational axis is tipped by a large angle relative to its orbit. Both circumstances in combination cause this effect.

As the heliocentric distance of the Neptune–Triton system doesn't change very much over a sidereal period of about 165 yrs, due to Neptune's nearly circular orbit, Triton's seasons are caused by a combination of exceptional orbital plane and spin axis orientations and the influence of Triton's orbital precession period (~680 yrs). Triton's orbital inclination wrt Neptune's equator is 157° (an inclination over 90° means retrograde motion) while Neptune's axis is tilted by ~30° against its orbital plane. Thus Triton's spin axis tilt wrt Neptune's orbit can vary between 127° and 180° (the current value is 130°),

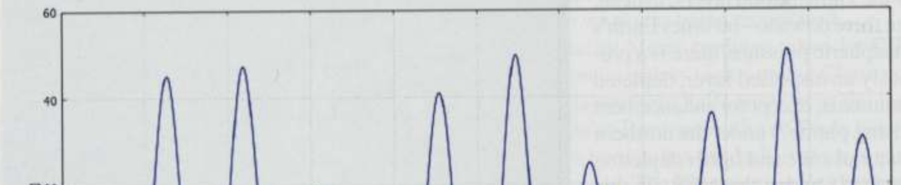

Figure 1. In the year 2000 Triton underwent an 'extreme' solstice, where the sub-solar point reached 50° South. This happens about every 650 yrs. The following events (in time order) are marked by a dot: (1) The *Voyager 2* flyby in 1989 August; (2) the stellar occultations of 1997 Jul 18 and (3) 2008 May 21 and (4) the upcoming stellar occultation of 2017 Oct 05. Data computed with IMCCE's Miriade service (http://vo.imcce.fr/webservices/miriade/).

Table 1. Main occultation data and circumstances for the UK

Date	Thursday 2017 October 5
Observing time for UK	23:48 UT ± 5 to 10 minutes (suggested recording time)
Star position (Gaia DR2)	RA 22 54 18.4364; Dec −08 00 08.318
Star magnitude	12.7V, 12.5R, 12.4I (APASS magnitudes)
Triton magnitude	13.5V
Magnitude drop	1.4 mag
Maximum duration	161 sec

giving it extreme seasons. The superimposition of Neptune's 165 yrs orbital period and Triton's ~680 yrs orbital precession period results in a double sinusoidal waveform as the Sun (or the latitude of the sub-solar point) shifts alternately north and south with a varying amplitude (see Figure 1).

Currently the southern hemisphere of the satellite is being illuminated by the Sun, after centuries of winter. Every 650 years a hemisphere faces an 'extreme solstice', as was the case in 2000 for Triton's southern hemisphere, where the sub-solar latitude reached 50° south.

From occultation observations in 1997 Elliot *et al.*[2] derived a global warming on Triton and a significant increase of atmospheric pressure since the 1989 *Voyager 2* flyby.

Another 10 years passed before another stellar occultation by Triton was successfully recorded.[3] Unfortunately the geometry of the chords (two almost grazing chords at the southern limb) limited the derived astrometry and therefore, within a 3-sigma confidence level, no significant value of the atmospheric pressure (and possible changes since 1997) could be derived. It is important to note that with occultation chords from the 2017 October 05 occultation, these data from 2008 can be re-analysed and possibly a reliable result for the atmospheric pressure can be retrospectively obtained.[4]

Scientific rationale

The stellar occultation technique is a very powerful tool for probing and monitoring planetary atmospheres. Not only can the atmospheric pressure be measured, but also haze layers can be detected through multi-wavelength observations, and by observing the so-called central flash, wind regimes in the atmosphere can be analysed.

Key questions are:

- What is the current atmospheric state (pressure)?
- Are there any (drastic) changes since the 1990s?
- Are the haze layers seen by *Voyager 2* in 1989 still present?
- Can wind regimes be constrained from central flash observations?

Predictions

Occultation predictions for this event are provided by several sources. For example by theEuropean Research Council (ERC) Lucky Star project group (**http://lesia.obspm.fr/lucky-star/predictions**) and by the author on his website (**http://astro.kretlow.de/?Occultation-Predictions**). See also Figure 2. The main occultation circumstances for the UK are given in Table 1.

Observation campaigns

Further information in addition to practical tips and suggestions will be available from a variety of websites, like the International Occultations Timing Association, European Section (IOTA-ES) (**http://iota-es.de**), BAA ARPS (**http://britastro.org/asteroids**) and dedicated individual webpages.[5,6] Announcements on mailing lists like PLANOCCULT and the release of a BAA e-bulletin are also planned.

It is noteworthy that SOFIA (Stratospheric Observatory for Infrared Astronomy) is also scheduled to observe this occultation.[7,8]

Some practical issues

1. The elongation to the full Moon will be only 34° at the time of occultation.
2. The angular separation between Neptune and Triton will be ~12 arcsec at occultation time. The use of a Barlow lens might be indicated for a better separation of the planet and the satellite.
3. Neptune will be much brighter and probably saturated on most cameras, so it cannot be used as a photometric reference object.
4. It is important to measure the target (occulted) star against reference stars on at least one night before (or after) the event, when the stars and Triton are clearly separated). This makes it possible to calculate the contribution of the occulted star to the total flux (star + Triton) during the event, and then to subtract Triton's flux from the lightcurve.

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References

1 Sicardy B. *et al.*, 'Large changes in Pluto's atmosphere as revealed by recent stellar occultations', *Nature* **424**, 168–170 (2003)
2 Elliot J. L. *et al.*, 'Global warming on Triton', *Nature* **393**, 765–767 (1998)
3 Sicardy B. *et al.*, 'The Triton stellar occultation of 21 May 2008', *EPSC 2008* abstracts (2008)
4 Sicardy Bruno, *pers. communication* (2017 July)
5 Webpage by Tim Haymes, Assistant Director (Occultations), BAA Asteroids & Remote Planets Section. **http://www.stargazer.me.uk/call4obs/NextEvent.htm**
6 Webpage by Mike Kretlow, **http://astro.kretlow.de**
7 Person M., 'A new look at Triton's atmosphere', *SOFIA Proposal, Cycle 5*, ID. 05_0125 (2016)
8 **https://eclipse2017.nasa.gov/content/sofia-triton-occultation-observations**

Tim Haymes (BAA ARPS) adds:

Many thanks to Mike for an excellent introduction to this important occultation.

Suggested instrumentation would be of long focal length (e.g. SCT or Newtonian + Barlow lens) and CCD/video at 1 sec exposure (say), shorter if possible. We recommend trial observations of Triton on an earlier night (preferably the night before), or during the lead up to the event itself. The occulted star will be brighter than Triton but a full Moon will also be close by, so it may be worthwhile erecting a temporary 'moonshade' to prevent moonlight entering the telescope directly. Since timing is important, computer clocks need to be sync'ed to UT. For more information on video & CCD monitoring of occultations, see the web pages referenced in Mike Kretlow's article.

The ARPS Section would be very pleased to receive visual observations from observers using telescopes of 30cm aperture or larger in good seeing. At 10 arcseconds separation from Neptune, the 12.5-mag star will be a difficult object but do give it a try! Visual observers could make audio recordings (*e.g.* with a smartphone), adding a UT time marker at the start and end of recording to a precision of ±0.5sec or better.

Please send observations to the ARPS (Dr Richard Miles, **arps@britastro.org**) copied to Mike Foulkes (Saturn, Uranus & Neptune Section), **mike.foulkes@btinternet.com**.

Good luck and clear skies!

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