# Astrometry of the Neptune-Triton System from OPD observations

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Triton is the main satellite of Neptune. Differently of the other regular ones, it has a retrograde, circular and high inclined orbit. Due to its orbital configuration, it's believed Triton was captured by Neptune (Mc-Kinnon and Kirk, 2007). Triton is one of the few objects in the Solar System that have an atmosphere. The extreme variation in the subsolar latitude in Triton causes strong variations in the distribution of frozen $N_2$ on its surface. This way, the polar cap of Triton can almost reach its equator (Hansen & Paige, 1992).

Neptune and Triton were observed by Voyage II spacecraft in 1989 (Smith et al., 1989), but it was only a close approach. The monitoring of their orbits and the study of Triton's atmosphere must be made from ground-based observations. The latter using the stellar occultation technique.

Our group has observed the Neptune-Triton system along time. This produced a large database with more than 5000 CCD observations since 1992 (Tab 1, Tab 2 and Fig. 1). More than 3000 of these observations have positions for both objects from the same image, which is important to improve the satellite's ephemeris. As comparison, Emelyanov and Samorodov (2015) produced new ephemeris for Triton from 10254 observations from 1847-2012.

Neptune is much brighter and demands short exposure time, but Triton ends underexposed with a low number of reference stars. With Triton well-exposed, Neptune ends saturated in the image. The reduction of Neptune's position still finds 2 difficulties: the differential Chromatic Refraction and its apparent size of 2.3", in the order of the seeing.

To correct the chromatic refraction (CR), we used a technique from Benedetti-Rossi et al. (2014) where the CR is modeled from the ephemeris offsets of the object. This technique was effective improving the offsets dispersion in Right Ascencion in the majority of the cases (Figs. 3 and 4). For Triton, due to its redder color, the technique was not effective.

Because of the size of Neptune, a numerical PSF which takes into account its phase angle is being tested so its photocenter can be improved.

Preliminary ephemeris offsets of Neptune and the difference between Triton's and Neptune's offsets are found in Fig. 5 and Fig. 6, respectively.

| Telescope | Neptune | Triton | Matches |
|---|---|---|---|
| 160 | 735 | 1251 | 682 |
| IAG | 2795 | 3341 | 2459 |
| Zeiss | 292 | 463 | 280 |
| Total | 3822 | 5055 | 3421 |

**Table 1**: Number of positions identified of non-saturated-Neptune and Triton by telescope. *Matches*: Number of positions where non-saturaded-Neptune and Triton were identified in the same image.

| Telescope | Clear | B | V | R | I | Metano |
|---|---|---|---|---|---|---|
| 160 | 569 | 4 | 5 | 5 | 86 | 13 |
| IAG | 919 | 21 | 126 | 243 | 1032 | 118 |
| Zeiss | 218 | - | - | - | 62 | - |

**Table 2**: Number of positions with Neptune and Triton in the same image by filter for each telescope.

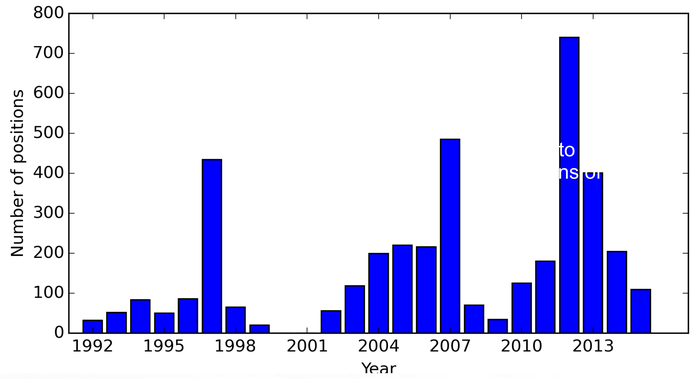


**Figure 1**: Distribution of positions with Neptune and Triton in the same image (short-exposure observations) by year.

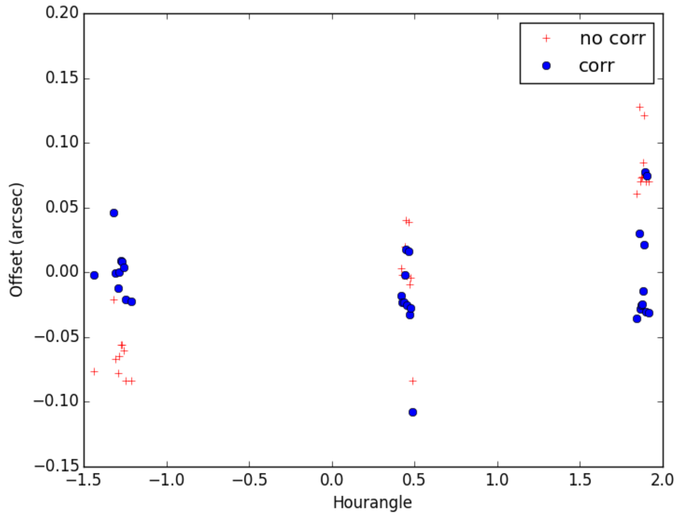


**Figure 3**: Offsets in right ascension before (red) and after (blue) CR correction for the night of August 20, 1993 observed with the Perkin-Elmer telescope.

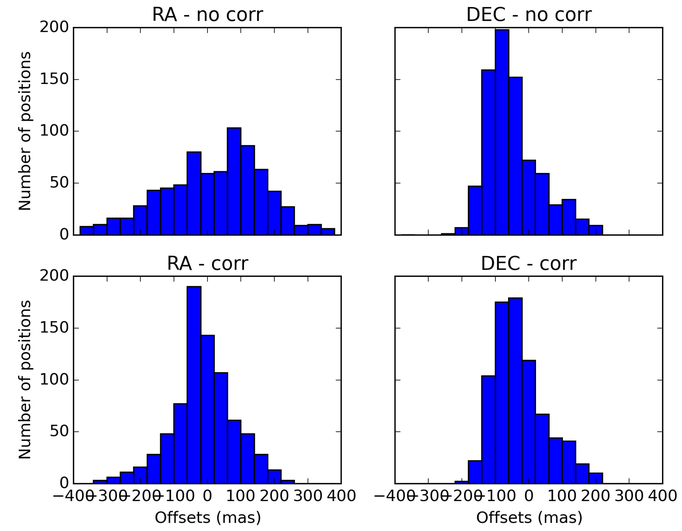


**Figure 4**: distributions of the offsets in RA and DEC before (no corr) and after (corr) the elimination of chromatic refraction for Neptune observed with the 160 telescope.

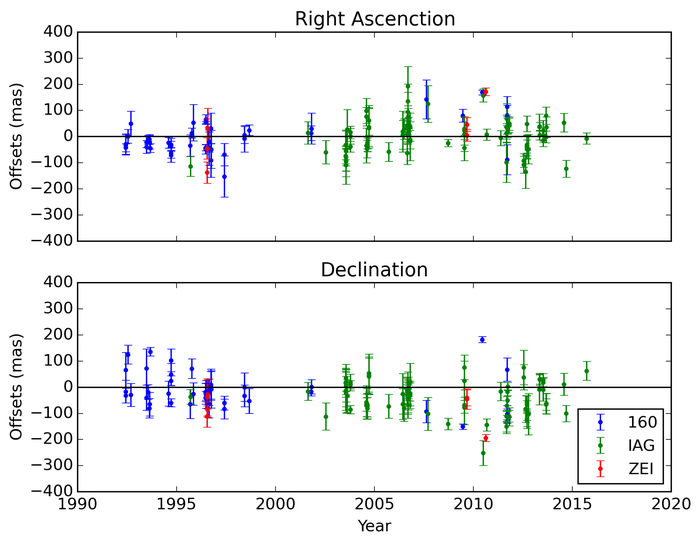


**Figure 5**: Neptune - Mean offsets by night. The plot shows the variation in the position of Neptune over time.

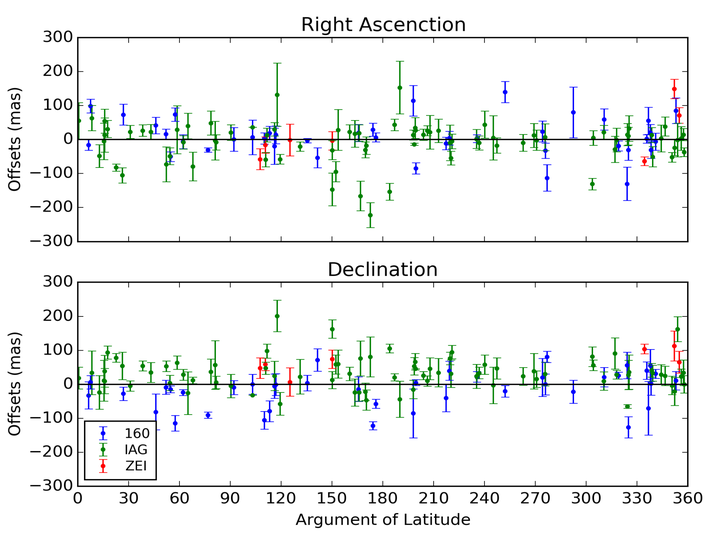


**Figure 6**: Difference between the offsets of Triton and Neptune by Argument of Latitude. It shows the variation in the position of Triton around Neptune.

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