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Solar system astrometry, Gaia, and the large surveys – a huge step ahead to stellar occultations by distant small solar system bodies

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Abstract. The stellar occultation technique is a powerful tool to study distant small solar system bodies. Currently, around 2 500 trans-neptunian objects (TNOs) and Centaurs are known. With the astrometry from Gaia and large surveys like the Large Synoptic Survey Telescope (LSST), accurate predictions of occultation events will be available to tens of thousands of TNOs and Centaurs and boost the knowledge of the outer solar system.

Keywords. astrometry, ephemerides, occultations, Kuiper Belt

1. Introduction

Stellar occultation is a powerful technique to study distant small solar system bodies. It allows high angular resolution of the occulting (solar system) body from the analysis of a light curve acquired with high temporal resolution. If, on the one hand, stellar occultations present difficulties – they are transient events and require accurate predictions – on the other hand they can be considered magnitude independent, in the sense that it is not necessary to detect light from the occulting body during the occultation. With the results from the Gaia space mission, stellar and bright TNO positions will be known with unprecedented accuracy. Also, using Gaia stars as references, ground based astrometry of solar system bodies will be known to the milliarcsecond level. In this context, deep sky surveys also play an important role. The LSST, for instance, will map the visible sky from Cerro Pachón about twice a week and observe objects as faint as r$\sim$24.5 in single images,

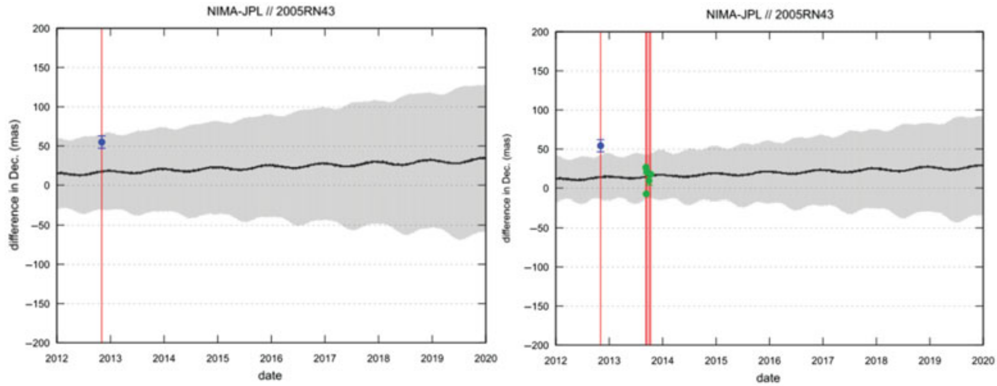

Figure 1. Black thick lines: differences in declination between the ephemeris determined by NIMA (Desmars *et al.* (2015)) and that from the JPL for the TNO 2005 RN43. Grey zones around thick lines: 1–σ uncertainty of NIMA's orbit. Left: orbit determination by NIMA using MPC data and averaged observations made at La Silla. Right: same as left panel plus observations from the DES. These latter observations were reduced with the Gaia DR1 (Lindegren *et al.* (2016)). Note that the uncertainties (grey zone) close to the dates of the most recent observations decrease considerably.

so that now we can have accurate predictions of stellar occultations for a large number of bodies, faint ones in particular. In other words, the prediction difficulty is overcome and the stellar occultation technique will now definitely be able to shed light on a so far "hidden" world of faint objects, telling us about their sizes and shapes, presence of atmosphere, and also about their immediate neighbourhoods.

2. Overview

We used public images taken by the Dark Energy Survey (DES) that were available at the NOAO archive (early 2015) to check the improvement in the orbit accuracy (Fig. 1). With accurate positions well distributed over few years, orbital accuracies better than 10 mas up to 1-3 years after the latest observation can be expected.

The LSST will increase the number of known TNOs by a factor ∼16 (or ∼40 000 objects) with new discoveries. In addition to a vibrating future that Gaia and the large surveys will bring to the study of the outer solar system through stellar occultations, a context of big data must also be considered.

3. Acknowledgement

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References

Desmars, J., Camargo, J. I. B., Braga-Ribas, F., *et al.* 2015, *A&A*, 584, 96
Lindegren, L., Lammers, U., Bastian, U., *et al.* 2016, *A&A*, 595, 4

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