EPSC Abstracts
Vol. 10, EPSC2015-309, 2015
European Planetary Science Congress 2015

JWST observations of stellar occultations by transneptunian objects and centaurs

P. Santos-Sanz (1), R. G. French (2), Z-Y. Lin (3), N. Pinilla-Alonso (4), J. Stansberry (5), Z-W. Zhang (6), J.L. Ortiz (1) and R. Duffard (1)

(1) Instituto de Astrofísica de Andalucía-CSIC, Granada, Spain, (2) Department of Astronomy, Wellesley College, Wellesley, MA 02481, USA, (3) Institute of Astronomy, National Central University, Jhongli City, Taoyuan County 32001, Taiwan, (4) Department of Earth and Planetary Sciences, University of Tennessee, Knoxville, 37996 TN, USA, (5) Space Telescope Science Institute, 3700 San Martin Drive, Baltimore, MD 21218, USA, (6) Institute of Astronomy and Astrophysics, Academia Sinica, P.O. Box 23-141, Taipei 10617, Taiwan (psantos@iaa.es)

Abstract

We investigate the capabilities provided by the James Webb Space Telescope (JWST) for the study of transneptunian objects (TNOs) and centaurs by means of the stellar occultation technique [1]. The strengths and weaknesses of this technique are evaluated in light of JWST's unique capabilities. We identify several possible JWST occultation events by TNOs and centaurs from 2018 to 2023, and evaluate their potential scientific value [1]. We also explore the possibility of serendipitous stellar occultations by very small TNOs as a by-product of other JWST observing programs.

1. Introduction

The observation of stellar occultations by solar system objects is a very powerful technique. Obtaining the timing of disappearance / reappearance of a star behind the object's limb from different locations, allows to obtain different chord lengths and to determine a very accurate size ($\sigma \sim 0.1\%$) and shape for these bodies. The detection of atmospheres, satellites, and the discovery/characterization of ring systems (as those detected around the centaurs Chariklo [2] and Chiron [3]) are other relevant products that we can obtain from stellar occultations.

Stellar occultations by Pluto were the first occultations by a TNO predicted and detected, and illustrate very well the power of this technique [4], [5]. Apart from Pluto, the observation of stellar occultations by TNOs is a relatively new field: only ~ 17 occultations by 9 TNOs have been recorded so far from ground-based telescopes (*e.g.* [6], [7], [8]), heightening the importance of identifying opportunities with other facilities, like space-based telescopes such as HST and JWST.

Stellar occultations are also a powerful tool to explore outer solar system small objects, whose sky-plane density is large enough to generate serendipitous stellar occultations. From these serendipitous occultations we can detect tiny objects invisible by direct imaging (*e.g.* [9]).

Both kinds of stellar occultations (predictable and serendipitous) require high-SNR and high time resolution observations of faint target stars which can be provided by JWST.

2. Predictable stellar occultations

Predictable stellar occultations are those that can be anticipated, i.e. it is possible to estimate when the occultation will occur, and where it will be visible. The main difficulty of this technique lies in the prediction of the events, which are rare due to the extremely small apparent size of the TNOs/centaurs (typically ~10 mas or even smaller) and the uncertainties in the orbit determination (due to the short arc of the orbit observed). The situation has improved spectacularly over the last few years thanks to improved ephemerides and star catalogues, and it will improve even more in the next years with the GAIA catalogue.

There is an additional source of uncertainty to predict occultations visible from JWST which is the position of the observatory in its orbit around L2 point. The expected accuracy of the JWST ephemeris is currently under study, and will be an important factor in estimating how well one can predict stellar occultations well in advance of the event.

Unfortunately, for occultations observed from JWST it is likely that only a single-chord will be obtained, since the event geometry will not provide the opportunity to observe the same occultation from ground-based (or space-based) observatories. However, even a single-chord occultations can be scientifically valuable [10]. For example, a single-chord observation could detect localized or global atmospheres at ~10 nbar level [7, 8]. With sufficiently high SNR, it could allow the retrieval of vertical profiles of atmospheric pressure and temperature. Single-chord occultations also provide the opportunity for serendipitous discovery and characterization of satellites and rings around TNOs or centaurs.

3. Serendipitous stellar occultations

Besides the predictable stellar occultations technique we can detect random stellar occultations, i.e. detect the diffraction shadow pattern in serendipitous stellar occultations by small numerous TNOs [9, 11]. These serendipitous occultations have no other competing methods, as the magnitudes of the corresponding objects, V ∼ 35 mag or fainter, are unreachable through classical ground-based –or even space-based– imaging. The method is successful if the sky density of objects is sufficient to result in a significant number of observable events.

Such occultations can reveal the vertical and radial distribution of the TNOs as far as 50 AU and beyond (kilometre-sized objects could be detected at ∼ 500 AU). Also, they provide information on the size distribution down to hectometre-sized and smaller objects, which is a key constraint to characterize the collisional history in the transneptunian belt.

The Fine Guidance Sensor (FGS) is a key component of the JWST Attitude Control System (ACS), and could be used as a unique instrument for high-speed photometry as well because it will image guide stars at a cadence of 16 Hz. We propose using FGS to detect serendipitous stellar occultations by TNOs, as a sub-product of other observing programs.

References

[1] Santos-Sanz, P., French, R. G., Lin, Z-Y., et al. 2015, submitted to PASP.

[2] Braga-Ribas, F., Sicardy, B., Ortiz, J. L., et al. 2014, Nature, 508, 72.

[3] Ortiz, J.L., Duffard, R., Pinilla-Alonso, N., et al. 2015, A&A, 576, A18.

[4] Hubbard, W.B.; Hunten, D.M.; Dieters, S.W., Hill, K.M., & Watson, R.D. 1988, Nature, 336, 452.

[5] Elliot, J.L.; & Young, L.A. 1992, Astronomical Journal, 103, 991.

[6] Elliot, J.L., Person, M.J., Zuluaga, C.A., et al. 2010, Nature, 465, 897.

[7] Sicardy, B., Ortiz, J. L., Assafin, M., et al. 2011, Nature, 478, 493.

[8] Ortiz, J. L., Sicardy, B., Braga-Ribas, F., et al., 2012, Nature, 491, 566.

[9] Roques, F., Georgevits, G., & Doressoundiram, A. 2008, The Solar System Beyond Neptune, 545-556.

[10] Alvarez-Candal, A., Ortiz, J. L., Morales, N., et al., 2014, A&A, 571, A48.

[11] Roques, F., Boissel, Y., Doressoundiram, A., Sicardy, B., & Widemann, T. 2009, EM&P, 105, 201