Stellar Duplicity Discovered During Occultation by Jupiter Trojan (347299) 2011 OA28

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Abstract

On December 25, 2024 an occultation of the star UCAC4 491-151065 (Gaia DR3-ID 2761012308826210816) by Jupiter Trojan (347299) 2011 OA28 revealed that the star is a previously unknown double star. Since only one positive chord could be observed during the observation of the occultation, multiple solutions were derived. The distance between the two double star components was determined to be 4.3 ± 0.0 mas and the possible position angles are 55.1° ± 0.1° and 100.1° ± 0.1°, respectively.

1. Introduction

In addition to determining important asteroid data such as size and shape, the main aim of observing stellar occultations by asteroids, information about the star can also be obtained, e.g. previously unknown double or multiple stars can be discovered. The Occult4 database[1] currently lists 266 double stars discovered during asteroidal occultations.

The occultation of the star UCAC4 491-151065 (Gaia DR3-ID 2761012308826210816) by Jupiter Trojan (347299) 2011 OA28, which was the first one observed by this asteroid, has been recorded by two different Swiss stations on December 25, 2024. One recorded light curve of the target star showed two consecutive unequal drops of the light curve, thus indicating stellar duplicity. According to the catalogs (Washington Double Star Catalog, Interferometric Catalog and Gaia Catalog), the star is not known as a double star. The Occult4 database does not contain any previous occultations of this star.

The observation took place within the framework of the International Occultation Timing Association/European Section (IOTA/ES)[2] and the result was recorded with its SODIS (Stellar Occultation Data Input System) portal[3]. No further observations of this occultation event are known.

2. Predictions

The occultation event has been predicted by the 'IBEROC' feed of Occult Watcher Cloud[4] using Occult4. Figure 1 shows Occult4 generated prediction details and a map[5] with the occultation shadow path and the recording station positions within Switzerland. Some relevant Gaia DR3 data of the occulted star are listed in the following Table 1.

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[1] http://www.lunar-occultations.com/iota/occult4.htm
[2] https://iota-es.de/index.html
[3] https://sodis.iota-es.de
[4] https://cloud.occultwatcher.net/event/1454-347299-330795-648518-U151065
[5] https://cloud.occultwatcher.net/event/1454-347299-330795-648518-U151065/2150722

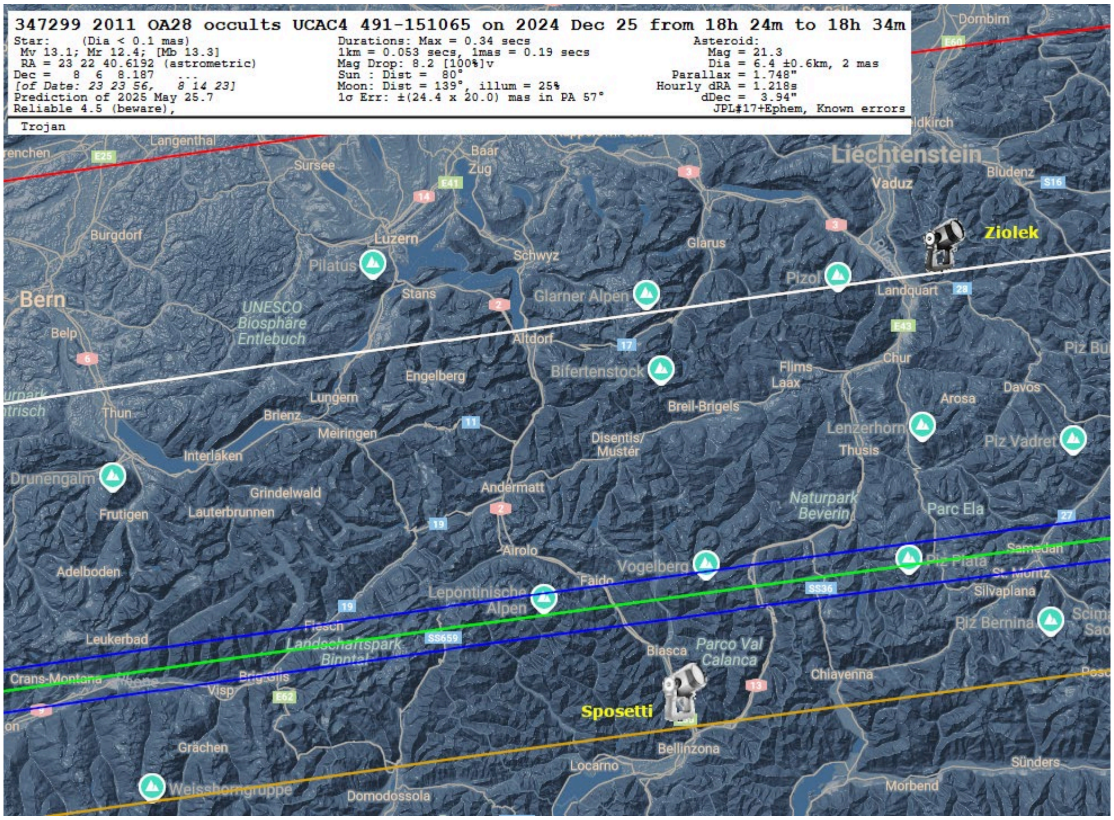

Figure 1: Predicted occultation shadow path with recording stations (yellow) and occultation event details of Jupiter Trojan (347299) 2011 OA28 occulting the star UCAC4 491-151065, map source: map.google.com

Table 1. Gaia DR3 data of the occulted star UCAC4 491-151065.

Gaia DR3 - ID	2761012308826210816
RA (J2000.0)	23h 22m 40s.6473
DE (J2000.0)	+08° 06' 08".3596
Proper motion in RA	- 1.13 ms/yr
Proper motion DE	- 6.9 mas/yr
G, R, B magnitude [mag]	13.07, 12.39, 13.35
RUWE	4.514
Duplicated source	No

3. Equipment and Observation

Both stations were using the Global Positioning System (GPS) 1PPS signal for time measurement, resulting in time accuracies in the range of 1 ms (Kamiński et al. 2023). The mirror telescopes had apertures of 356 mm and 420 mm respectively and no photometric filter was used. Both cameras were of the Complementary Metal-Oxide-Semiconductor (CMOS) monochrome sensor type and used either a Sony IMX430 or a Sony IMX174 sensor. Further details are listed in Table 2.

Table 2. Technical details of the recording stations.

Station	Telescope aperture [mm]	Focal length [mm]	Camera	Timing source	Exposure time [ms]	Event type
Ziolek	356	2971	DVTI+CAM 430	GPS	75	pos
Sposetti	420	1640	QHY174M GPS	GPS	160	neg

Station Sposetti recorded no occultation of UCAC4 491-151065 whereas station Ziolek recorded an occultation event, consisting of two consecutive unequally deep target star light curve drops. Figure 2 illustrates the relevant sections of the light curves of the target star obtained at both stations.

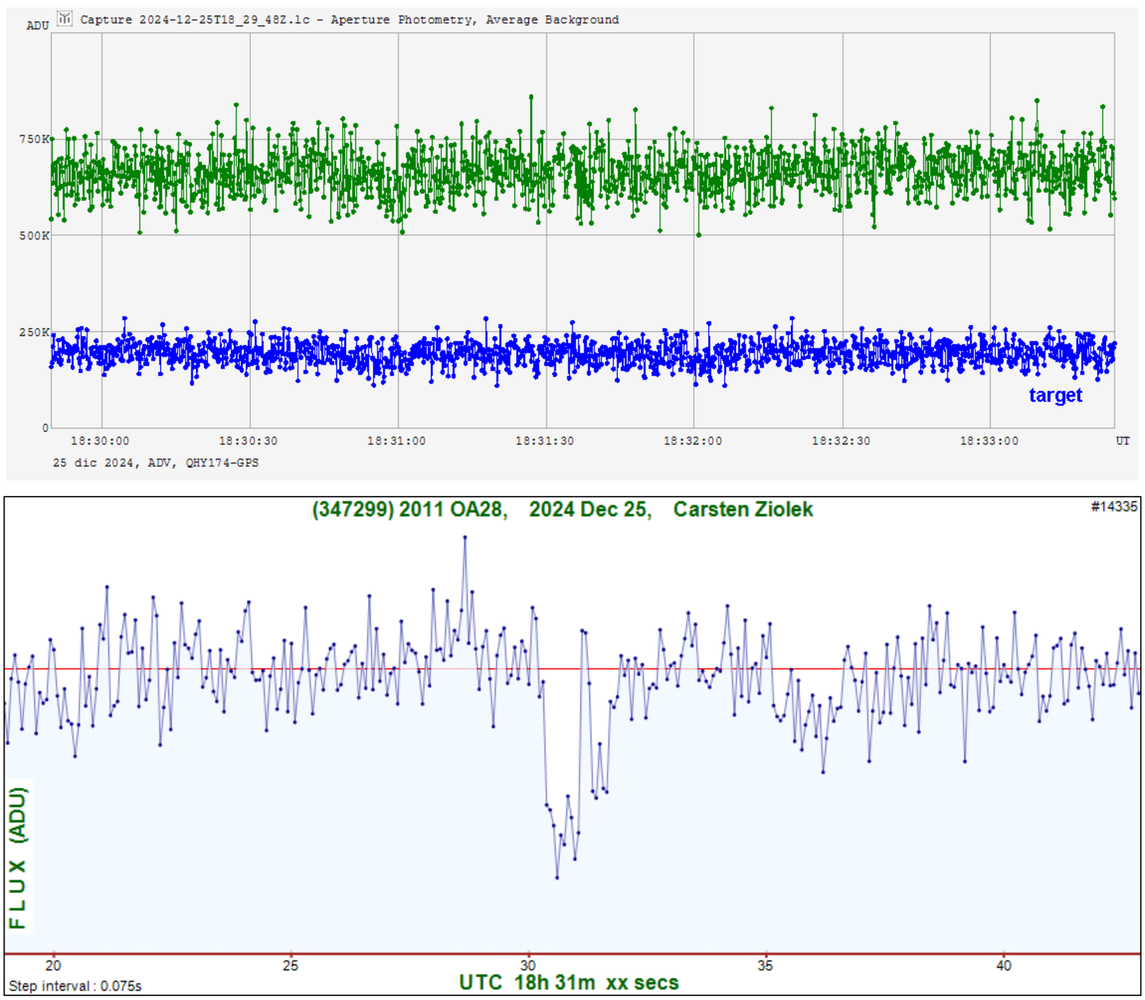

Figure 2: Light curves of the target star at the stations Sposetti (top) and Ziolek (bottom) showing no or two consecutive, unequally deep, light curve drops.

4. Photometry and data reduction

For the photometry of the recording, station Sposetti used Tangra[6] and station Ziolek used PyMovie[7]. To extract the occultation times and the average light level steps we used PyOTE[8]. Figure 3 shows the reduction for station Ziolek and Table 3 lists the derived event times and light level steps. The light levels and their sequence show that the components are occulted in the order A-A-B-B.

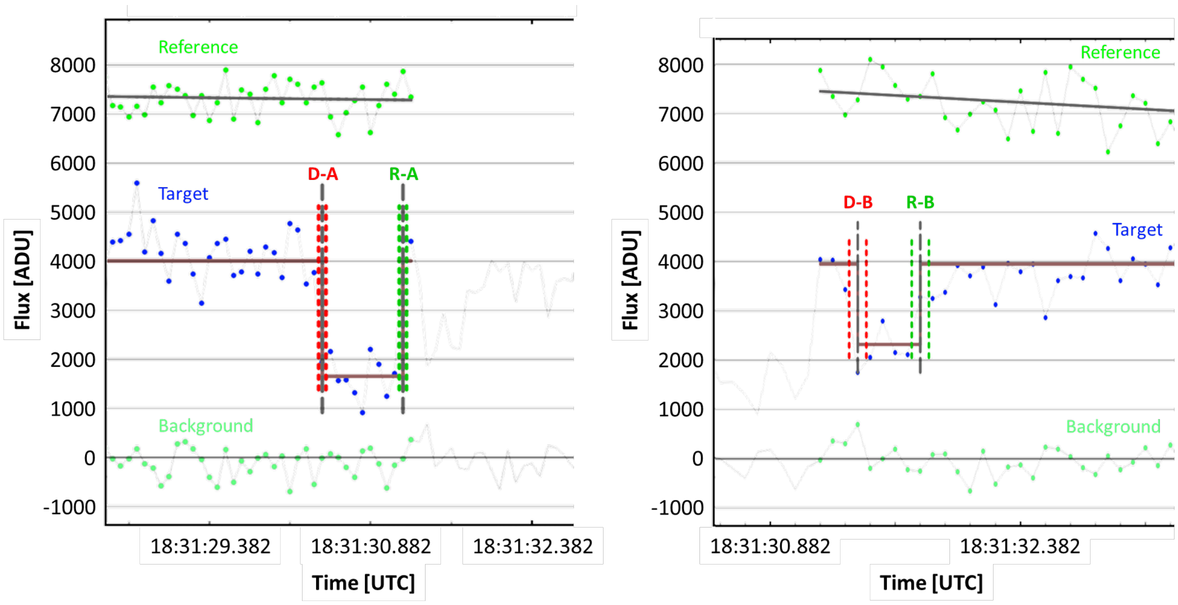

Figure 3: Station Ziolek event times extractions with PyOTE, for results see Table 3. A is double star main component, B secondary component, D disappearance, R reappearance. Target light curve is blue, reference and background light curves are green

Table 3. PyOTE derived event times and light level steps (compare Fig. 3); A, B stellar components designation, D disappearance, R reappearance, Δ X light level step in mag.

Station	D-A (UTC) [h:m:s]	R-A (UTC) [h:m:s]	Δ A [mag]	D-B (UTC) [h:m:s]	R-B (UTC) [h:m:s]	Δ B [mag]
Ziolek	18:31:30.43 ±0.04	18:31:31.18 ± 0.04	0.96 ± 0.18	18:31:31.41 ± 0.05	18:31:31.78 ± 0.05	0.58 ± 0.18

5. Analysis

For the analysis, we used the corresponding tools from Occult4 by applying the standard method described in (Herald et al. 2009). Since the length of the longer chord is about 13.9 km and thus much larger than the previously known diameter of the asteroid of 6.6 km, it is assumed that there is only a single location for this chord, which is aligned with the center of the asteroid. Therefore, only two different double star solutions #1 and #2 are possible instead of four. Figure 4 shows the results of the double star analysis.

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[6] http://www.hristopavlov.net/Tangra3
[7] https://pypi.org/project/pymovie
[8] https://pypi.org/project/pyote

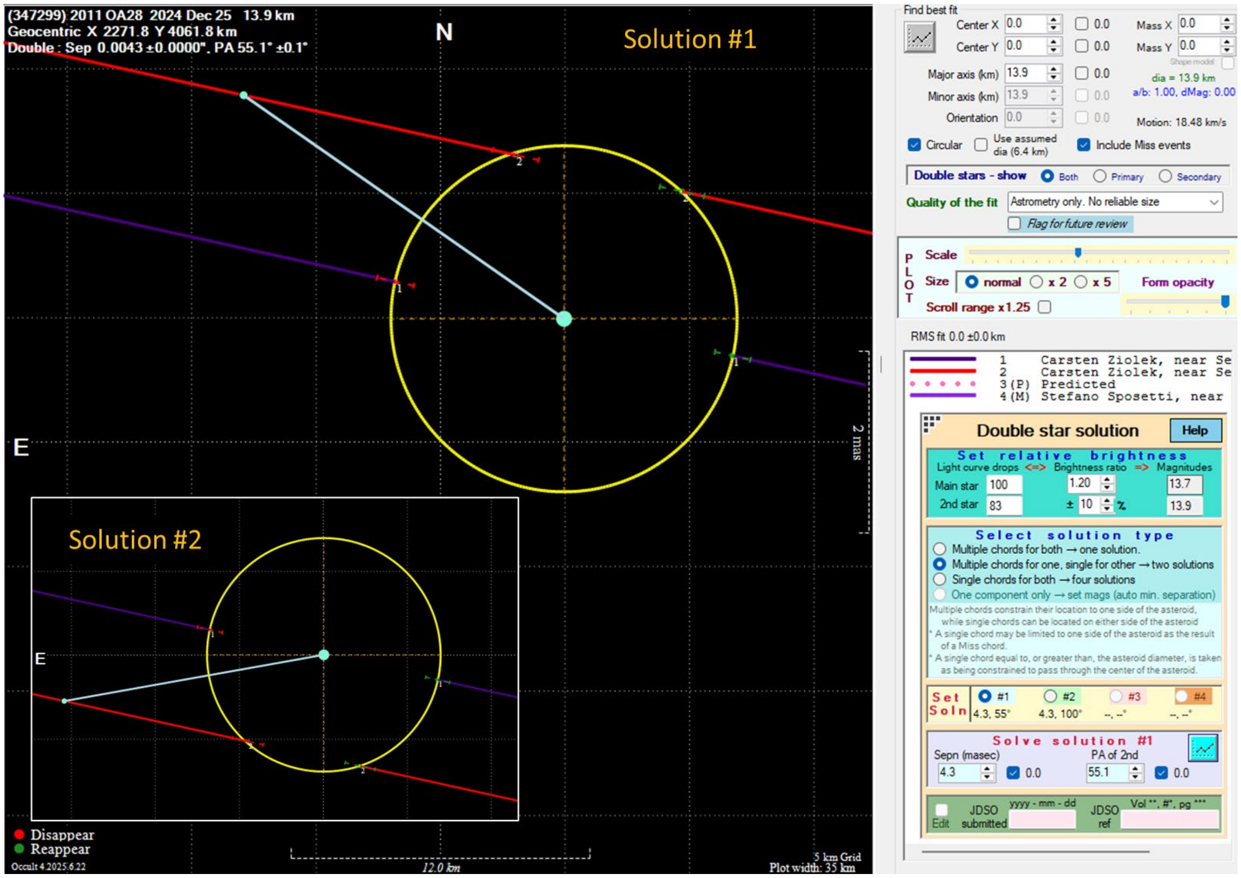

Figure 4: Occult4 double star analysis for Station Ziolek showing the resulting binary star solutions #1 and #2

6. Results

The two binary star solutions derived from the Occult 4 analysis are listed in Table 4.

Table 4. Double star characteristics as derived from the Occult 4 analysis.

Double Star Solution	Separation [mas]	Position angle [°]	G-band magnitude component A [mag]	G-band magnitude component B [mag]
#1	4.3 ± 0.0	55.1 ± 0.1	13.6 ± 0.2	14.0 ± 0.2
#2	4.3 ± 0.0	100.1 ± 0.1	13.6 ± 0.2	14.0 ± 0.2

Assuming a linear camera response, we calculated the magnitudes of the double star components A and B using the light curve magnitude drops given in Table 3. Using Occult4, we determined a Gaia G-band brightness of 13.6 mag ± 0.2 mag for the main A component and 14.0 mag ± 0.2 mag for the fainter B component (Table 4). More observations are needed to further improve the data.

7. Acknowledgements

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References

Herald, D., et al. (2009). New double stars from asteroidal occultations, 1971 – 2008. Journal of Double Star Observations, 6(1), 88-96. Retrieved from http://www.jdso.org/volume6/number1/herald.pdf

Kamiński, K., et al. (2023). Reaching Submillisecond Accuracy in Stellar Occultations and Artificial Satellite Tracking, 2023 PASP 135 025001. DOI https://doi.org/10.1088/1538-3873/acacc8

[9] https://www.cosmos.esa.int/gaia

[10] https://www.cosmos.esa.int/web/gaia/dpac/consortium