A New Double Star Detected During an Occultation by the Asteroid (409) Aspasia

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Abstract: On November 9, 2018 an occultation of the star UCAC4 435-115475 by the asteroid (405) Aspasia produced two successive magnitude drops, showing this star is a new double.

Occultation Circumstance

On 2018 November 9, an occultation of the star UCAC4 435-115475 by the Asteroid (405) Aspasia was predicted at our Latrape observatory with a probability of 96% (figure 1).

According to the astorb database of October 1, 2018, the shadow center of the ≈190 km diameter asteroid was passing only 22 km north from our site. We

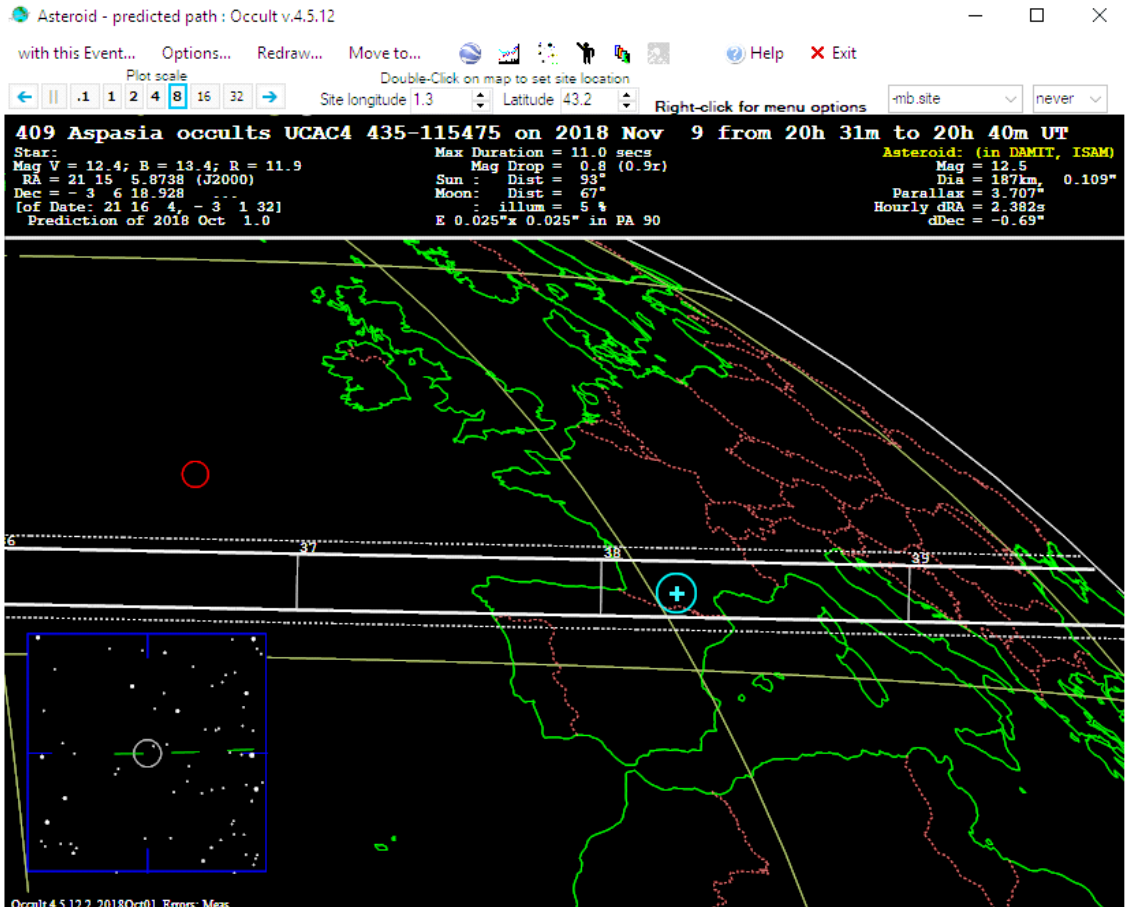

Figure 1: Occult 4 prediction for the occultation path

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were two observers at the same site, Michel Boutet and Jacques Sanchez with 12" and 14" SCT. We both used analog CCD video cameras (Watec 910HX/RC) at prime focus. Unfortunately, the 14" setup failed at the last minute, but the recording with the 12" setup, by Michel Boutet, was successful.

UCAC4 435-115475 parameters

The star coordinates (J2000) are (figure 2):
Alpha: 21h 15mn 05.8738s (astrometric)
Delta: -03° 06' 18.927" (astrometric)
The star of Vmag 12.4 is located in the constellation Aquarius (Aqr) and was at 31° elevation that day.

4UC435-115475
Overview of the UCAC-4 catalog
RA: 21h15m05.8846s +/- 54 milliarcseconds
declination: - 3 06' 18.857" +/- 34 milliarcseconds
(Above RA/dec is the J2000 value straight from the catalog, with no proper motion or other corrections applied)

Proper motion in RA: 13.0 +/- 4.6 milliarcsec/year
Proper motion in dec: 6.9 +/- 3.5 milliarcsec/year
UCAC instrumental "pseudo-R" fit-model magnitude: 12.430
UCAC instrumental "pseudo-R" aperture magnitude: 12.414
Error on above magnitudes is 7 millimags
Good star
Single star
6 UCAC images were taken; 4 were actually used
3 catalogues were used for proper motions
Not matched to Hipparcos or Tycho
AC2000 match flag: 1
NPM Lick match flag: 1
Running number within UCAC4 catalog: 98440871
UCAC2: 174-152230

Figure 2: UCAC4 star parameters

Double Star Occultation

The star is considered as single in the UCAC4 catalog and is not listed in the Washington Double Star catalog.

During the Aspasia occultation, two successive magnitude drops were observed while only one was expected: the first one lasted 7.60s at the expected time, at UT 20h 38mn 10s. A calculation with the Occult software and the astorb catalog of October 1 predicted an occultation at 20h 38mn 15s. A second unexpected occultation occurred 28.56s later, at UT 20h 38mn 46s and lasted 10.56s with a smaller mag drop.

The expected maximum occultation duration was 11.0s confirming we were close to the central line, especially for the second star.

The recording and the results analysis show clearly a double star (figures 3, 4, 5).

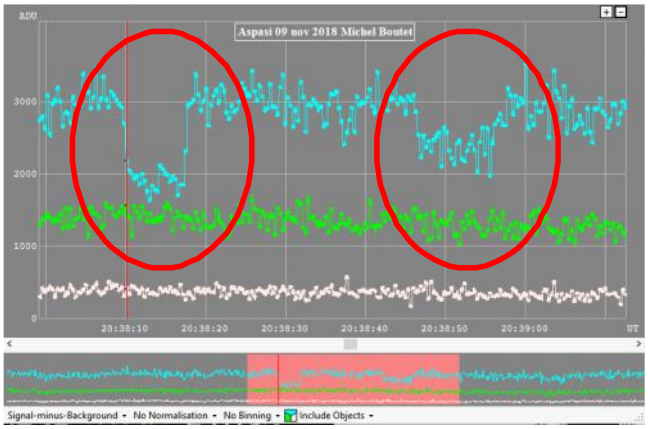

Figure 3: TANGRA[4] reduction of the video recording of the two occultations (blue curve). The reference stars (green and pink) are stable.

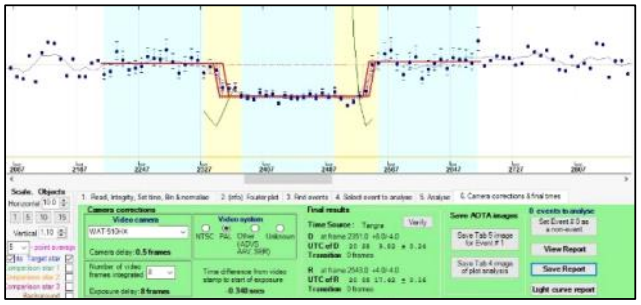

Figure 4: AOTA analysis of occultation 1 with Occult 4[3].

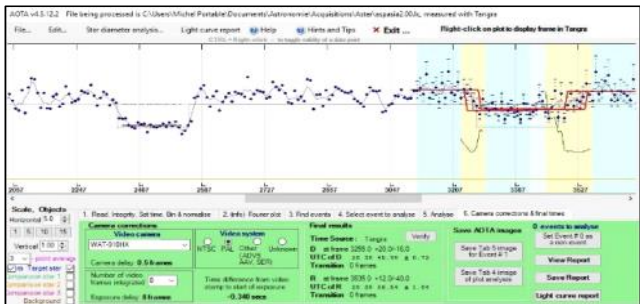

Figure 5: AOTA analysis of occultation 2 with Occult 4[3].

Occ1 timings:
D1 - 20:38:09.82 ± 0.24 disappearance
R1 - 20:38:17.42 ± 0.16 reappearance

Occ2 timings:
D2 - 20:38:45.98 ± 0.72 disappearance
R2 - 20:38:56.54 ± 1.04 reappearance

Double Star Magnitudes Evaluation

Analysis of the fluxes by Eric Frappa(1) gave a max flux (asteroid + stars) of 2961.6. The flux for Occ1 (the asteroid plus the secondary star minus the main star) was 1871.2 and the flux for Occ2 (the asteroid

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main star minus the secondary star) was 2457.9. Using the standard magnitude equation:

$\Delta m = -2.5 \log(Flux1/Flux2)$,

the Occ1 magnitude drop was estimated to 0.5 and the Occ2 magnitude drop to 0.2.

If we combine these flux drops into one, simulating a single star, we find a combined mag drop of 0.8 which is what was expected (figure 1).

Using the known asteroid magnitude of 12.5 and the star magnitude of 12.4, with the combined magnitudes equation,

$$m = m_1 - 2.5 \log (1 + \text{antilog} (-0.4 (m_2 - m_1)))$$

we can derive the magnitude of each component

main star mag = 12.8

secondary star mag = 13.7

Double star separation (Sep) and position angle (P.A.) evaluation

From the measured chords and the asteroid parameters, the double star characteristics can be derived. As there was only one observation, a unique solution cannot be found: the measured path can occur in one side or in the other side of the asteroid, giving the same measured timings. Four solutions exist. They have been estimated 'manually' by geometry but confirmed with more accuracy with the Occult4 software of Dave Herald[3] (Table 1 & figure 6), using the asteroid observations editor and its very good documentation. We assume a circular shape for the asteroid[2] and a diameter of 179.5 km.

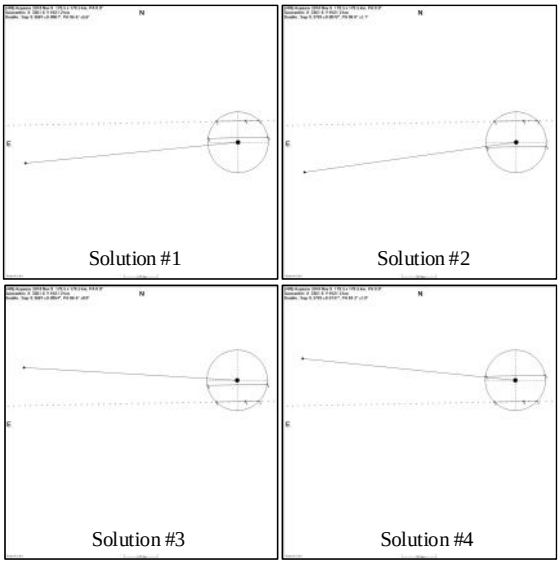

Figure 6: The four solutions for Sep and P.A. of the star components with a circular model of the asteroid.

All solutions are close to each other.

Further analysis with the real shape

Aspasia shape has already been modeled after photometric observations, three DAMIT and ISAM models are available (see an example on figure 7). All models show some small deviations from a circular shape.

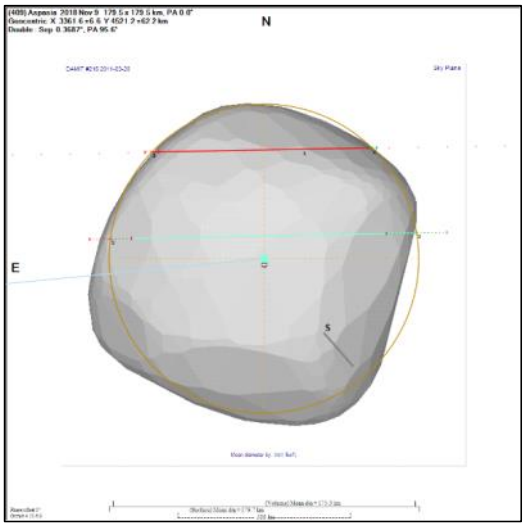

Figure 7: Example of DAMIT #215 shape model solution #1, showing Aspasia at the occultation time superimposed on the measured chords.

Evaluation of the best model fit:

For each model and each solution, we superimposed the asteroid modeled shape on the measured chords and measured graphically the deviations between them (Table 1).

Solution Model	#1	#2	#3	#4	Total/Model
DAMIT 215	6	23	16	5	50
DAMIT 715	9	19	41	16	95
ISAM 2	8	14	7	7	36
Total/Solution	23	56	64	28	

Table 1: Cumulated distances between chords and model shape (mm). Graphical / manual estimation on screen: the lower figure the better fit.

The best fits are for DAMIT #215 solutions 1 and 4, DAMIT #715 solutions 1 and 4 and ISAM #2 solutions 1, 3 and 4.

These rough estimations give a better probability for solutions 1 and 4 on which DAMIT 215 and ISAM 2 models give the best fit.

Summary

UCAC4 435-115475 is a double star found through an occultation by an asteroid. Four solutions for the characteristics are shown in Table 2, with more probability for solutions 1 and 4.

NAME	RA+DEC	MAGS	PA	SEP	DATE	N	NOTES
UCAC4 435-115475	211506-0306	12.8,13.7	95.6 ± 5.6	0.3687 ± 0.0061	2018.858	1	Solution 1
UCAC4 435-115475	211506-0306	12.8,13.7	98.0 ± 5.4	0.3703 ± 0.0068	2018.858	1	Solution 2
UCAC4 435-115475	211506-0306	12.8,13.7	86.6 ± 5.5	0.3687 ± 0.0060	2018.858	1	Solution 3
UCAC4 435-115475	211506-0306	12.8,13.7	84.2 ± 5.5	0.3703 ± 0.0069	2018.858	1	Solution 4

Table 2: UCAC4 435-115475 solutions with circular model

Acknowledgments / References

The author would like to acknowledge and thank Eric Frappa for his assistance in the analysis of these events.

(1)- Analysis and calculations of the stars magnitudes performed by Eric Frappa. http://www.euraster.net/

(2)- An occultation observation of (409) Aspasia show ing its roughly circular shape: http://www.euraster.net/results/2008/ in dex.html#0212-409

(3)- Dave Herald Occult software for lunar and aster oids occultations prediction and analysis including a module for double stars analysis through occulta tions. http://www.lunar-occultations.com/iota/ occult4.htm

(4)- Tangra3 is a software designed by Hristo Pavlov for reducing astronomical video observations such as asteroid occultations. http:// www.hristopavlov.net/Tangra3/