

Prediction of stellar occultations by the space telescope CHEOPS

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Summary

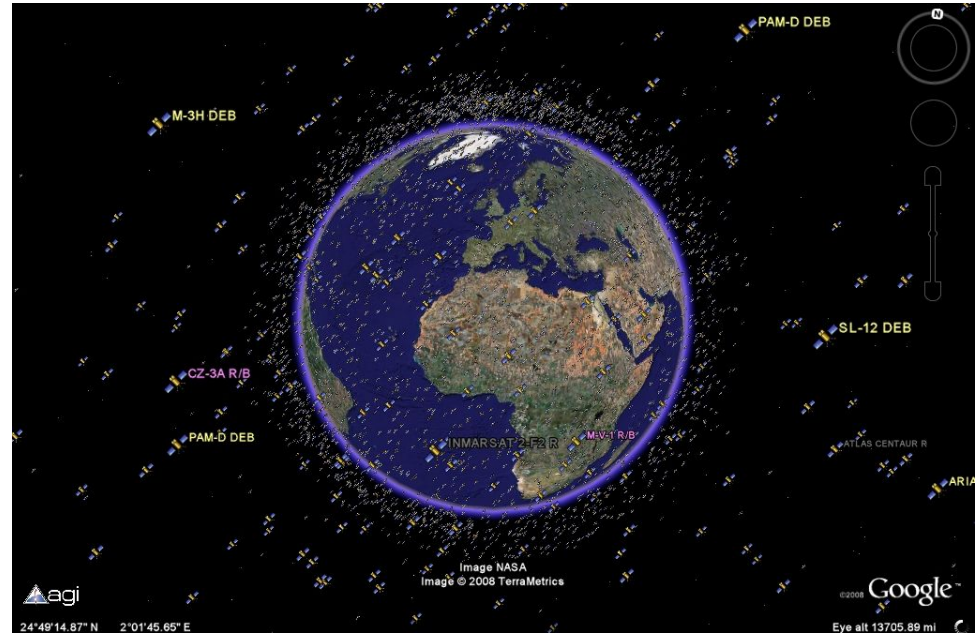
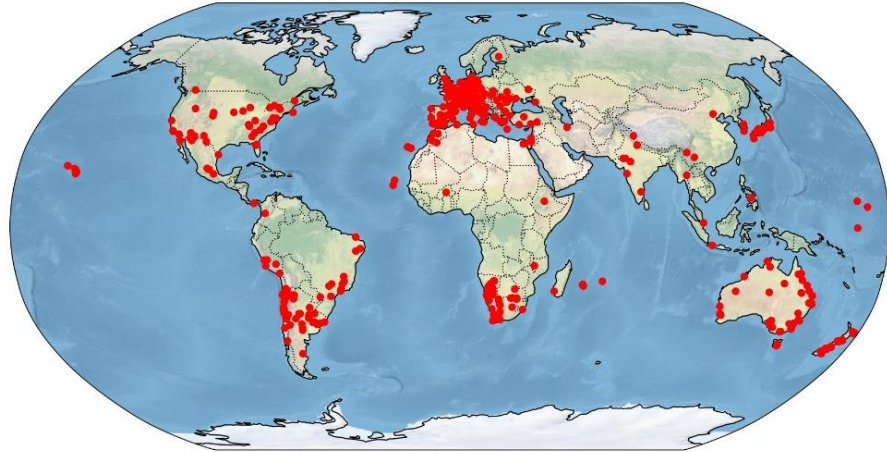


- Introduction;
- Observations from Earth x Observations from Spacecraft
- The Occultation by Quaoar observed by CHEOPS
- Predictions of stellar occultations to be observed by CHEOPS
- The Stellar Occultation by Triton in October 6th, 2022.

Introduction

- Stellar occultations observed by Spacecraft in-situ:
 - Cassini (Li et al. 2014).
 - New Horizons
- Stellar occultations observed by spacecraft orbiting Earth:
 - Hubble Space Telescope (HST) observed occultation by Saturn and its rings Elliot et al. (1993).
 - HST observed serendipitous occultation by small TNOs Schlichting et al. (2009, 2012).
- What about predicting and observing occultations for a small body using spacecrafts?

Observations from Earth x Artificial Satellites



Difficulties in observations by Spacecraft

Construction for dedicated observations:

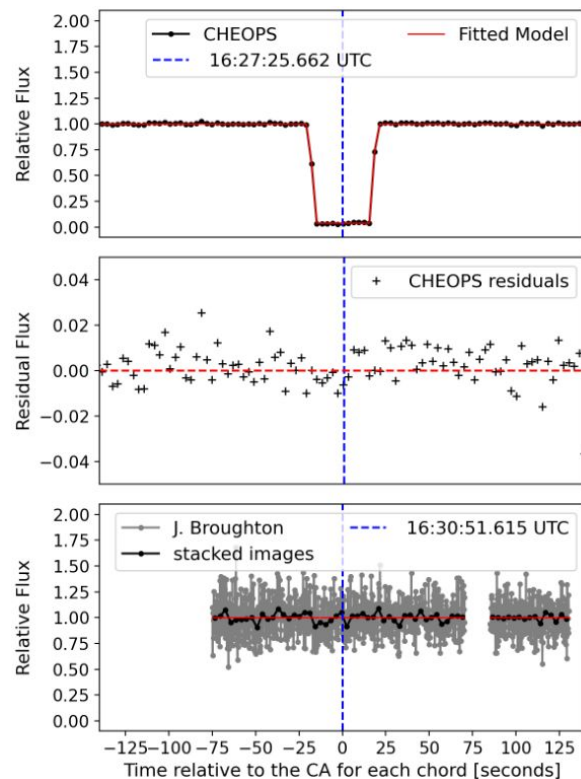
- Expensive;
- Required many Cubesats or spatial telescopes;
- Difficult in predicting stellar occultations;

Using already existing telescopes:

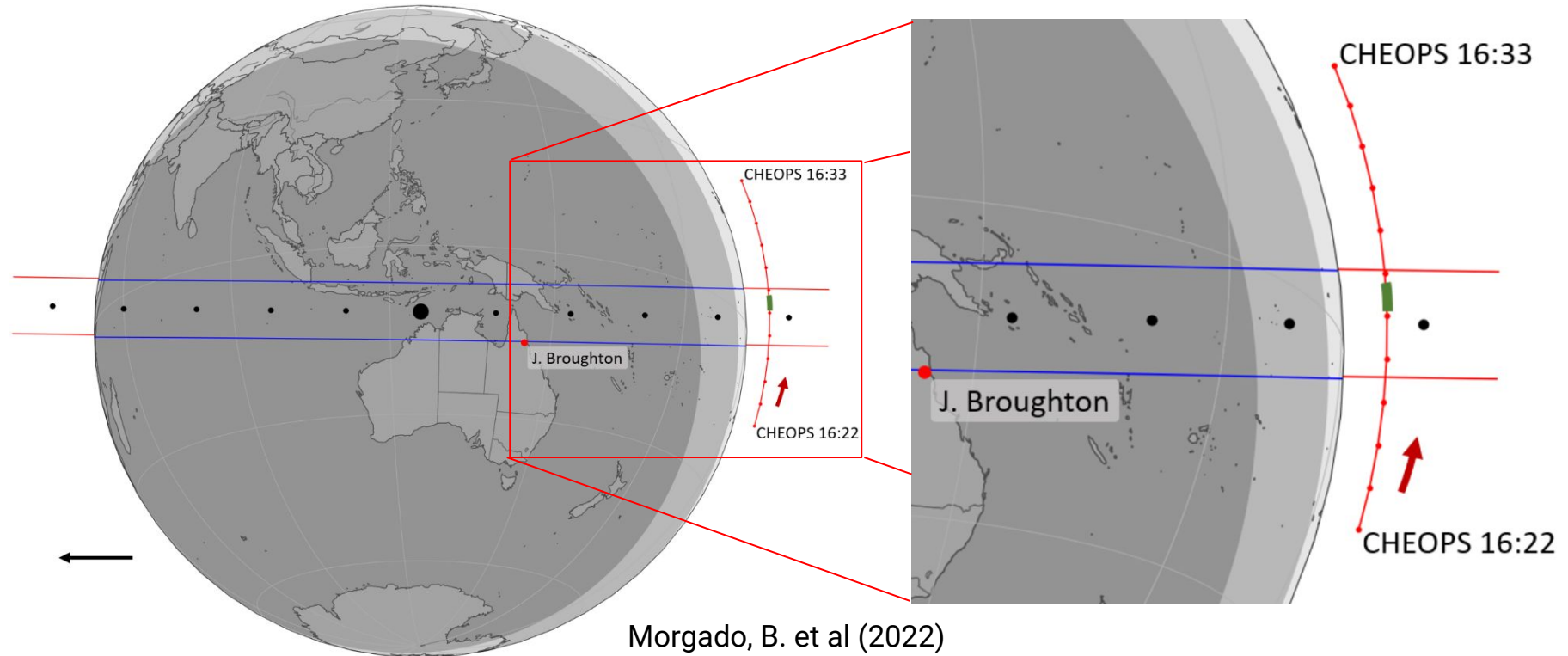
- Usually not the recommended equipment for occultations;
- Necessary to submit proposals of observations for each telescope;
- Difficult to have an orbit for the telescope:
 - Usually a good orbit is released 2-week prior to the event.

The Occultation by Quaoar observed by CHEOPS

- CHEOPS: CHaracterising ExOPlanet Satellite. Characterising exoplanets known to be orbiting around nearby bright stars
- Occultation by Quaoar on June 11, 2020.
- It was the first occultation by a TNO predicted and observed by an artificial satellite orbiting Earth;
- Published by B. Morgado, G. Bruno, A. R. Gomes-Júnior et al. (2022)



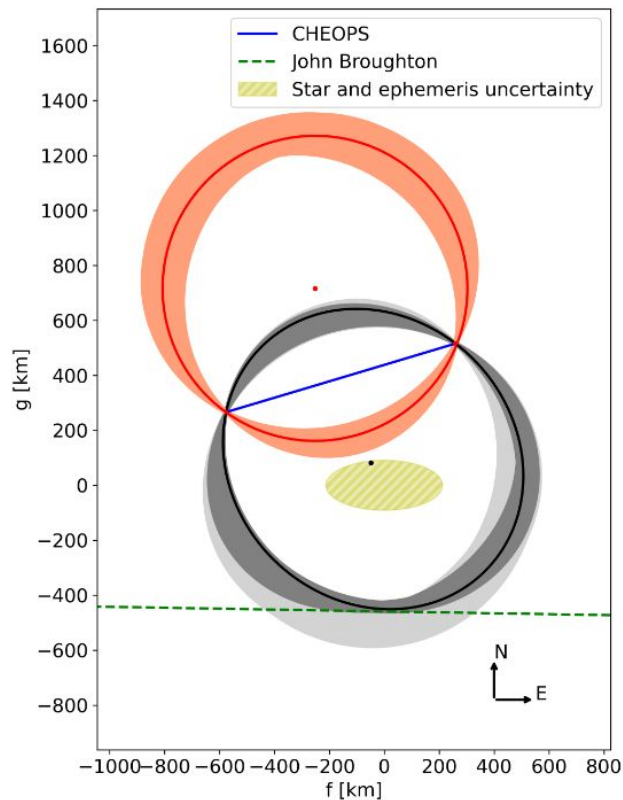
The Occultation by Quaoar observed by CHEOPS



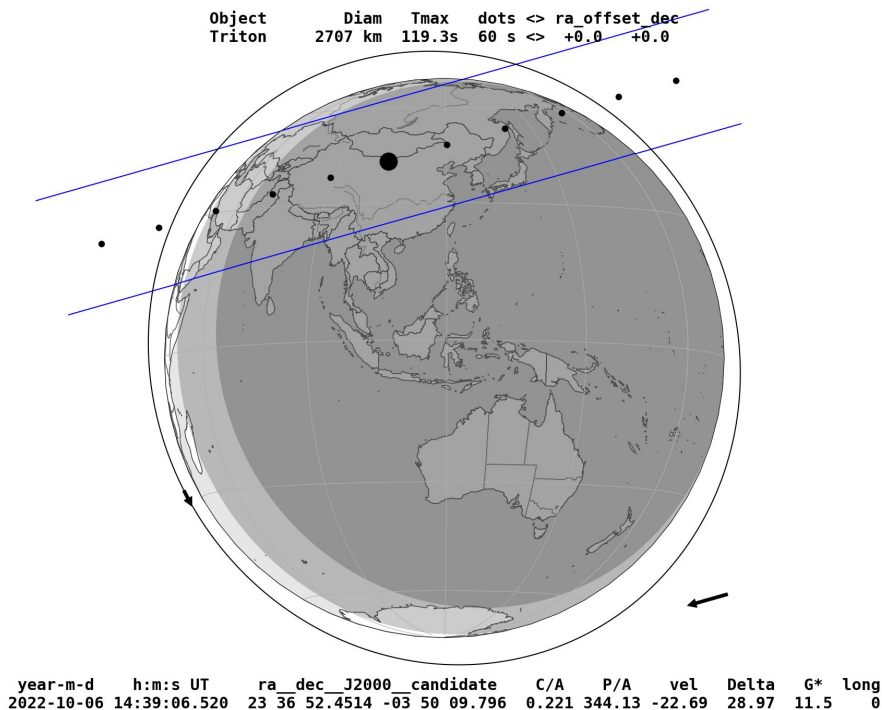
The Occultation by Quaoar observed by CHEOPS

Results:

- First detection of occultation by TNO from space telescope orbiting Earth;
- Astrometric position;
- Detection of material around Quaoar (not in this specific publication);



Prediction of occultations for CHEOPS



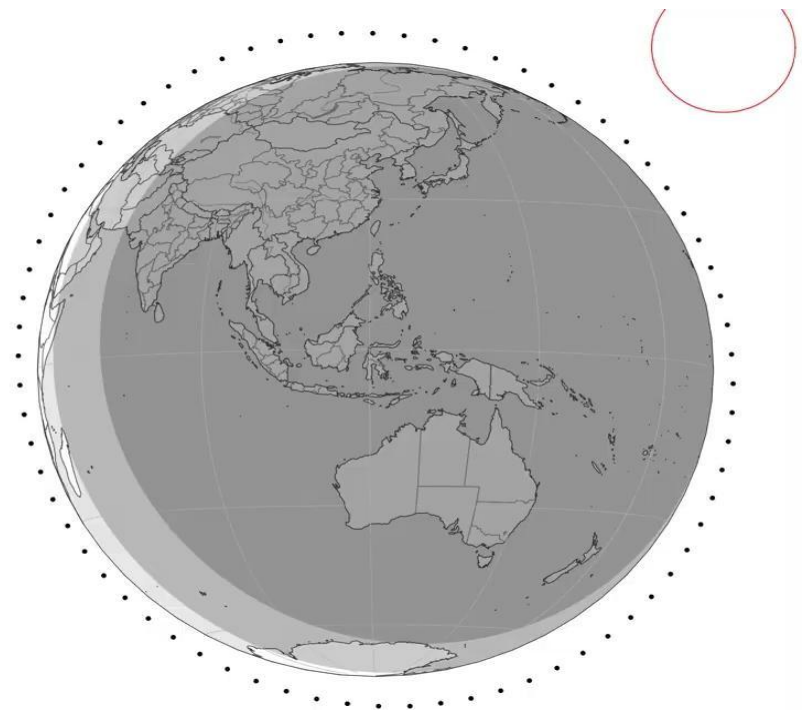
CHEOPS GUEST OBSERVERS PROGRAMME:

- Principal Investigator: Altair R. Gomes-Júnior;
 - Hours approved: 7.5h;
 - Number of events: 5;
 - Every observation with priority 1;
 - AO-3: 1 July 2022 to 24 September 2023.
-
- We invite everyone to observe the same events.

<- Prediction of Triton's occultation to be observed by CHEOPS.

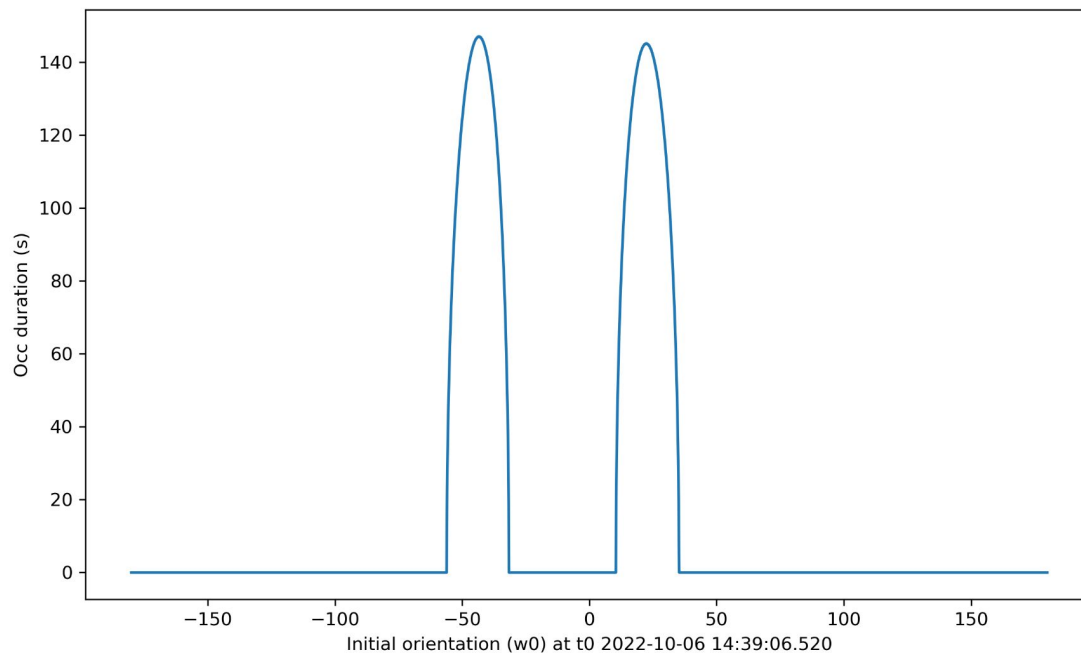
Prediction of occultations for CHEOPS

- Separation from the Moon larger than 5° ;
- Separation from the Sun larger than 120° ;
- Considering the orbit of Cheops:
 - We distributed many initial conditions for Cheops
- Considering an orbital period of 95 minutes;
 - We made the satellite orbit Earth at a constant rate;
- We calculated the number of initial conditions that would observe the occultation at any time.



Prediction of occultations for CHEOPS

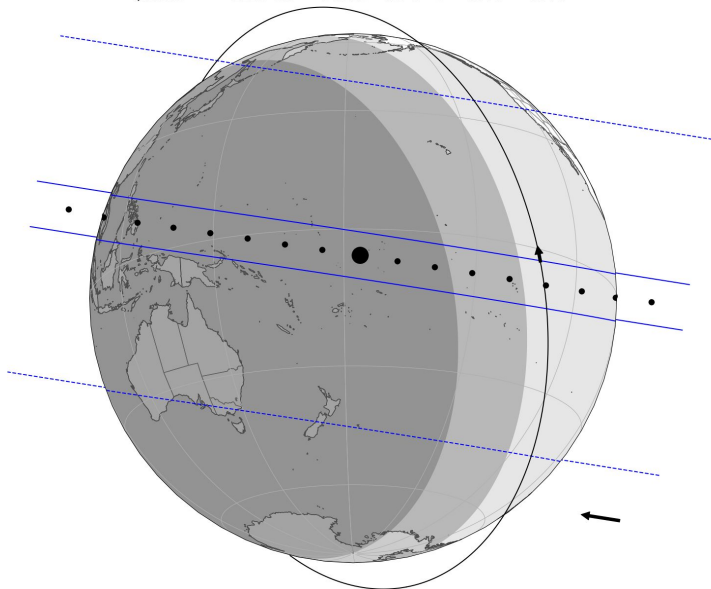
Probability in observing the Triton occultation: 14%



Prediction of occultations for CHEOPS

Probability: 3.3%

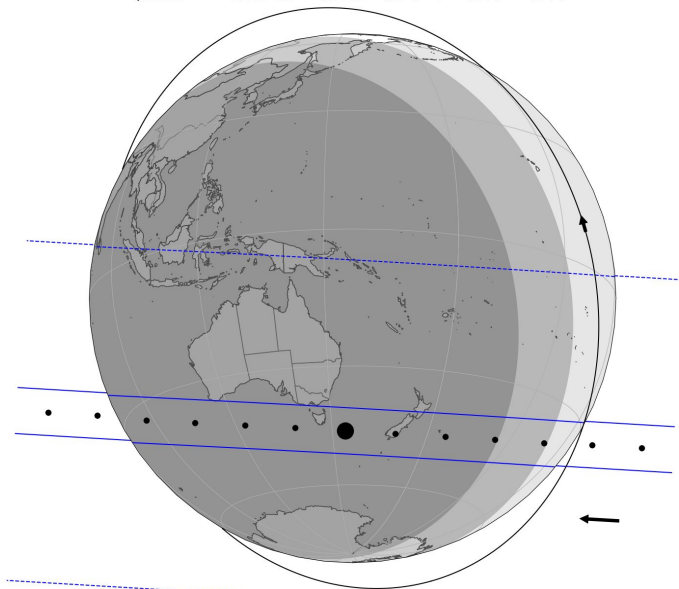
Object	Diam	Tmax	dots	<>	ra_offset	dec
Quaoar	1110 km	74.7s	60 s	<>	+0.0	+0.0



year-m-d	h:m:s UT	ra	dec	J2000	candidate	C/A	P/A	vel	Delta	G*	long
2023-05-10	15:14:14.720	18 33	39.8201	-15 05	09.279	0.034	8.99	-14.86	42.05	13.8	0

Probability: 3.4%

Object	Diam	Tmax	dots	<>	ra_offset	dec
Quaoar	1110 km	55.5s	60 s	<>	+0.0	+0.0

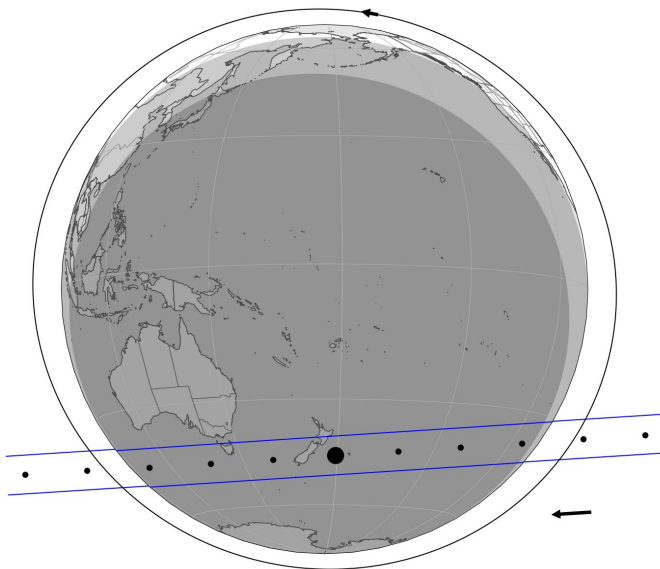


year-m-d	h:m:s UT	ra	dec	J2000	candidate	C/A	P/A	vel	Delta	G*	long
2023-05-26	15:53:06.820	18 32	44.9289	-15 03	48.979	0.105	183.40	-20.00	41.87	14.8	0

Prediction of occultations for CHEOPS

Probability: 6.7%

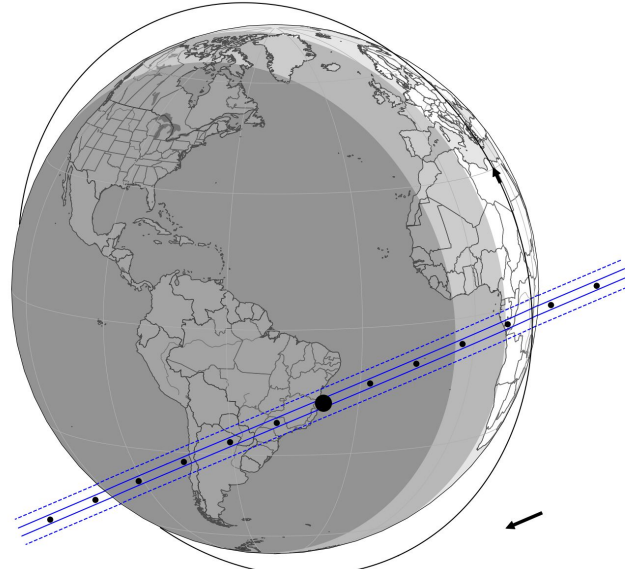
Object	Diam	Tmax	dots <>	ra_offset_dec
2002MS4	934 km	37.2s	60 s <>	+0.0 +0.0



year-m-d	h:m:s UT	ra_dec_J2000_candidate	C/A	P/A	vel	Delta	G*	long
2023-07-03	12:34:30.220	19 02 56.5560 -05 28 24.948	0.122	176.36	-25.08	45.29	14.2	0

Probability: 1.0%

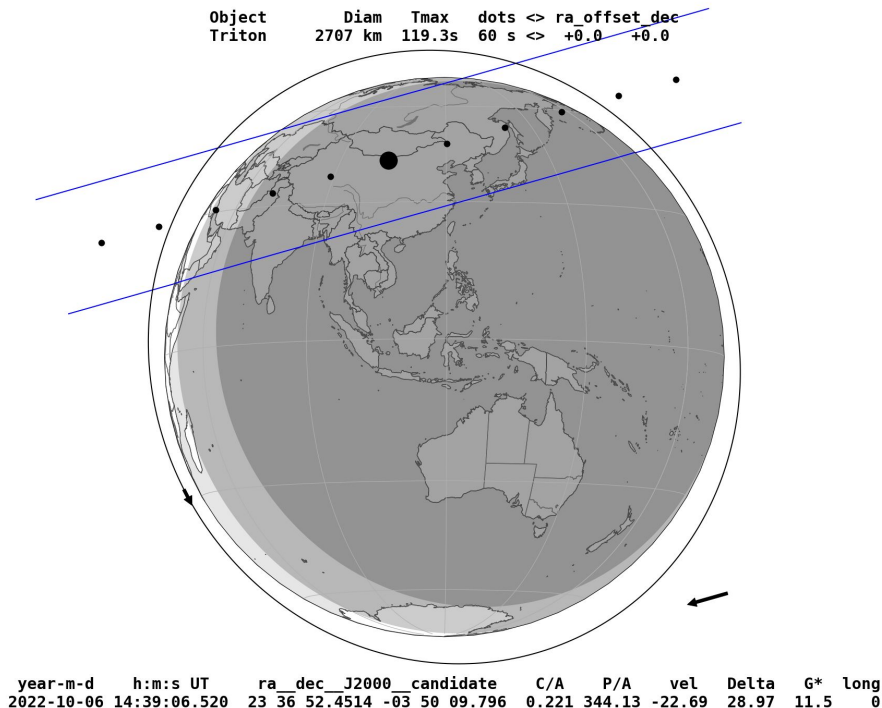
Object	Diam	Tmax	dots <>	ra_offset_dec
Chiron	210 km	10.5s	60 s <>	+0.0 +0.0



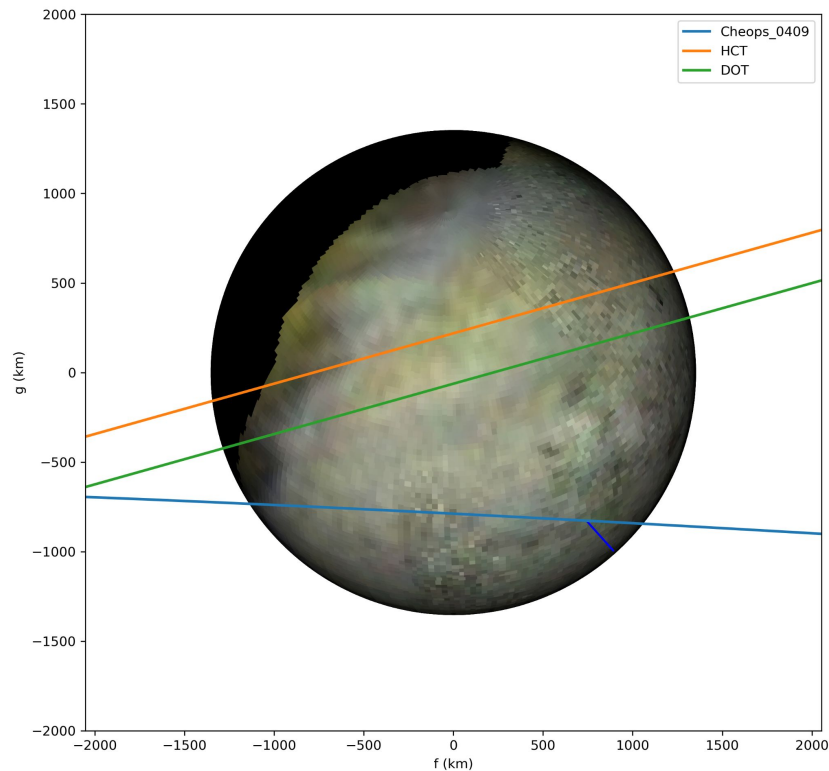
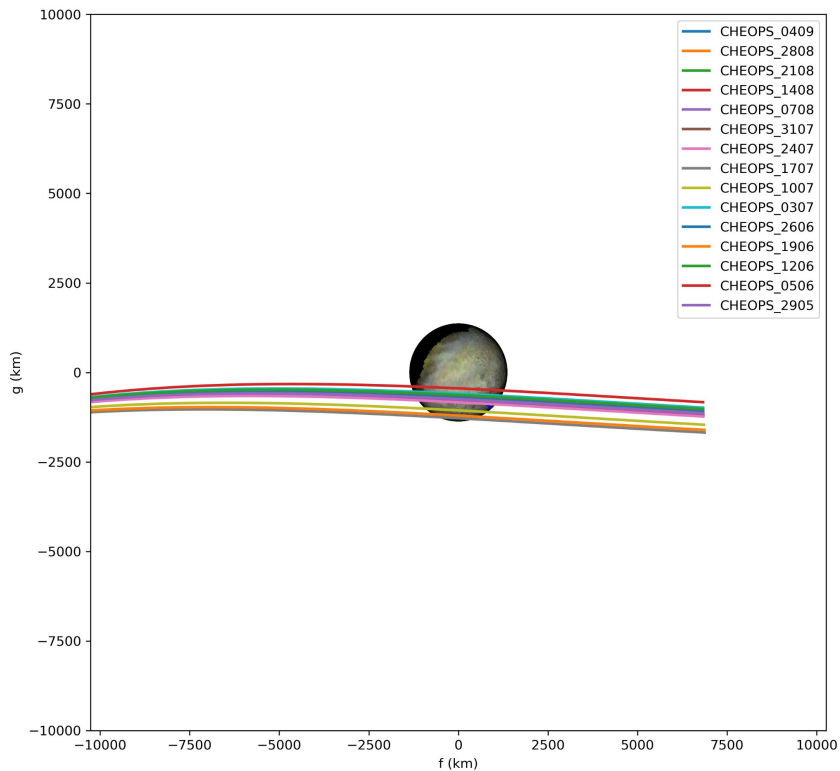
year-m-d	h:m:s UT	ra_dec_J2000_candidate	C/A	P/A	vel	Delta	G*	long
2023-09-10	05:09:10.300	01 06 30.3762 +08 44 41.751	0.229	156.92	-19.96	17.89	13.3	0

Stellar Occultation by Triton in October 6, 2022

- The predicted orbit of CHEOPS are released every Sunday with 4 months of data;
 - No uncertainty is informed;
- The restituted orbits are released daily;
 - A test shows a difference from prediction smaller than 2 km 3 weeks prior to the date, smaller than 30 km 6 weeks prior to the date, and larger than 110 km for more than 7 weeks, reaching 200 km in 14 weeks prior to the epoch.
- We are updating the orbit constantly and verifying the actual probability of observation.

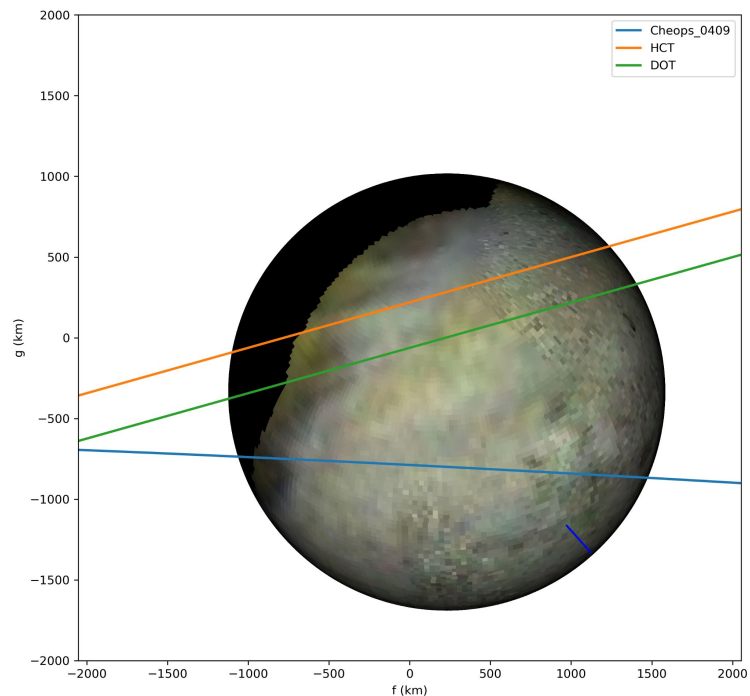
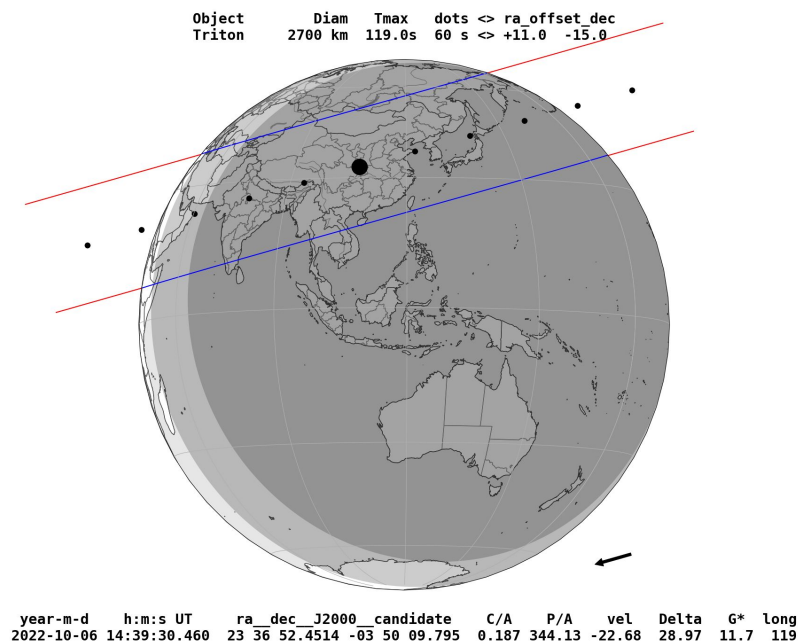


Stellar Occultation by Triton in October 6, 2022

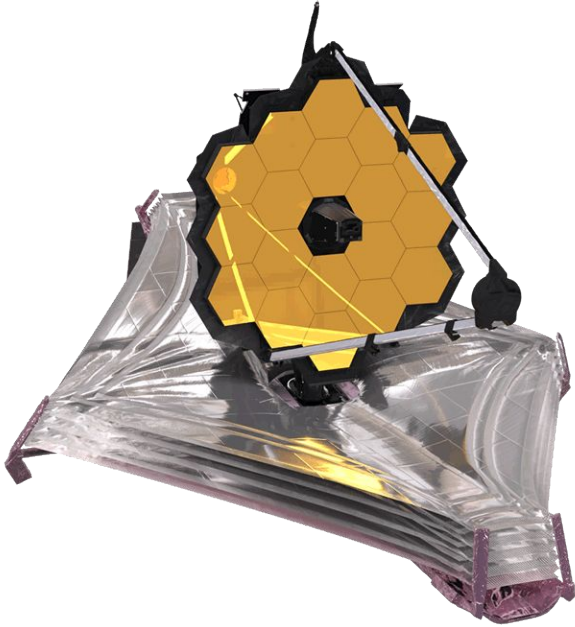


Stellar Occultation by Triton in October 6, 2022

Prediction corrected by astrometric positions obtained at Pico dos Dias Observatory, Brazil



Prediction of occultations for James Webb



- Next step in predictions for space telescopes;
- Presentation by Pablo Santos-Sanz;

Thank You