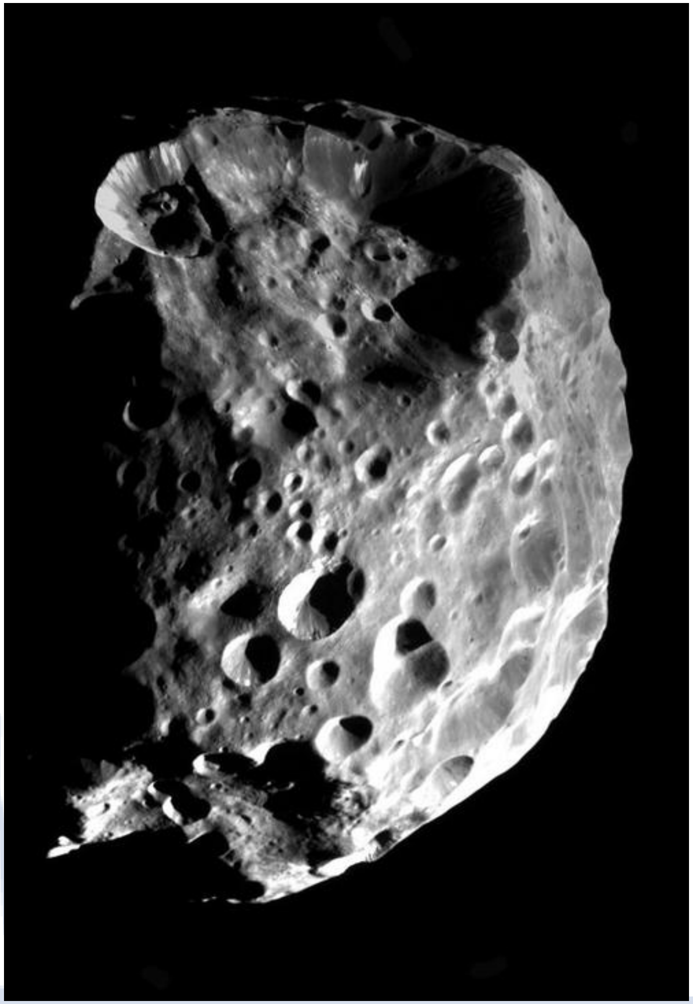
Predictions of Stellar Occultations by Irregular Satellites up to 2020



Phoebe
Source: *Cassini*

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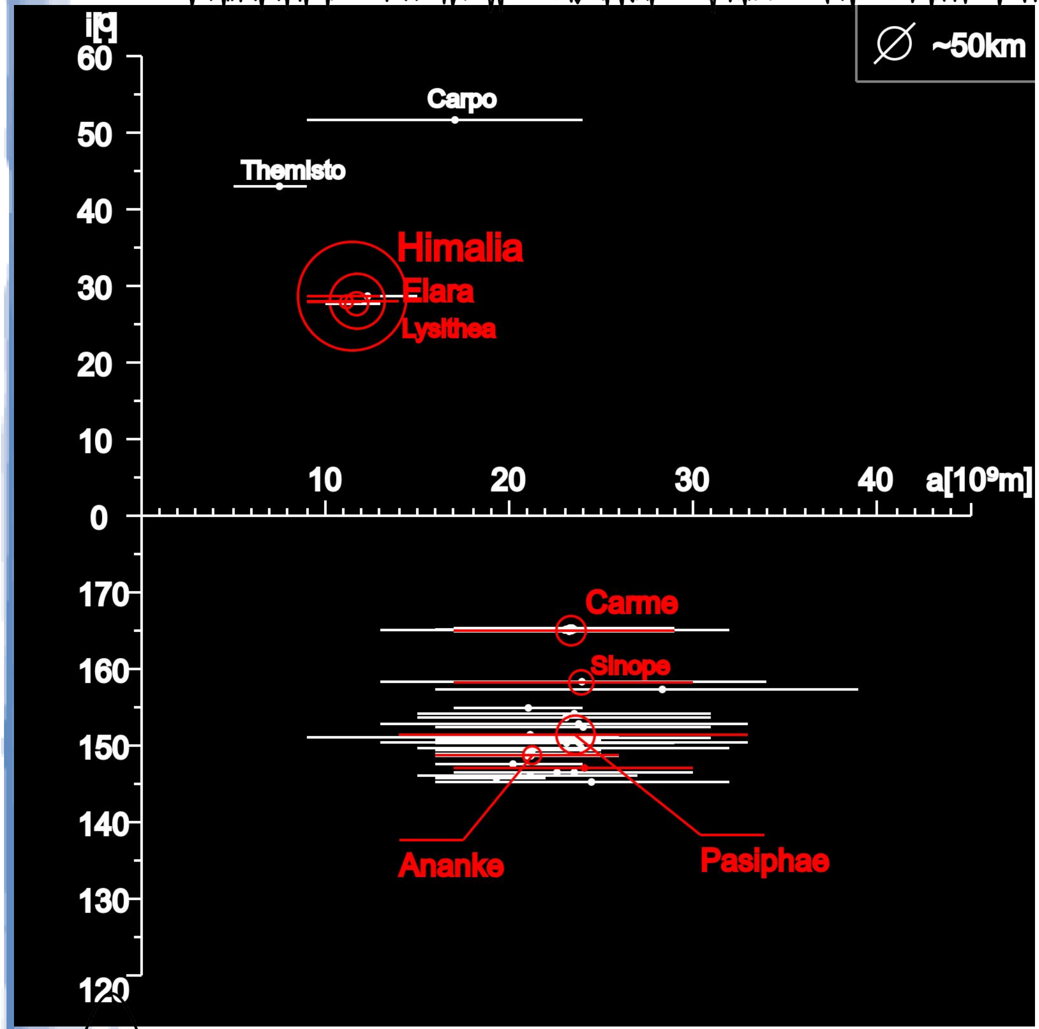
Irregular Satellites

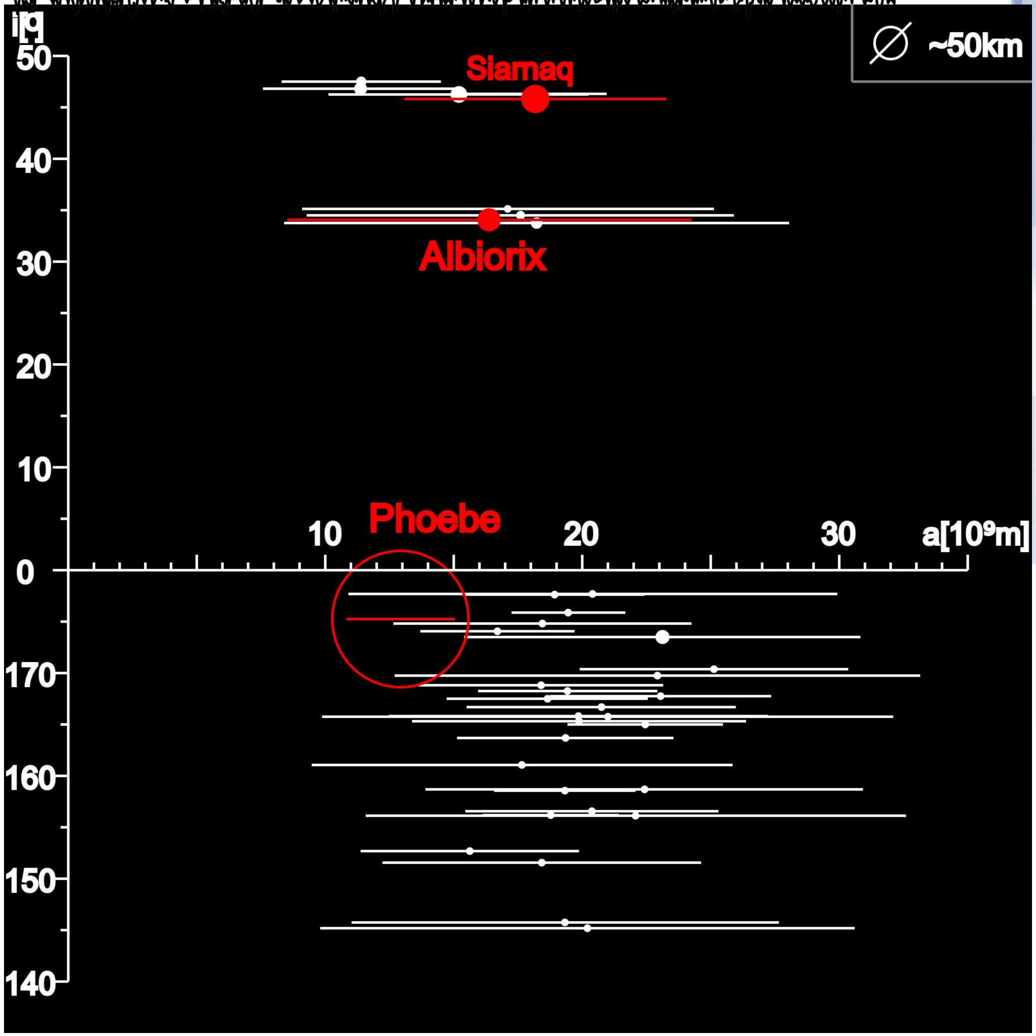
- Burns (1986): Satellites are irregular when their orbital planes precess primarily under the influence of torques from the Sun.

- Their orbits are eccentric, usually highly inclined and distant from their planets. The direction of their movements can be prograde or retrograde.

Irregular Satellites



Satellites of Jupiter



Satellites of Saturn

Irregular Satellites

- Capture:
  - Gas Drag (Cuk & Burns, 2003);
  - 3-body interation (Nesvorný et al., 2007);
  - Collision (Sheppard, 2006).

- Orbital Evolution:
  - Origin of the orbital family of satellites (Nesvorný et al., 2004);

Stellar Occultations of Irregular Satellites

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New orbits of irregular satellites designed for the predictions of stellar occultations up to 2020, based on thousands of new observations

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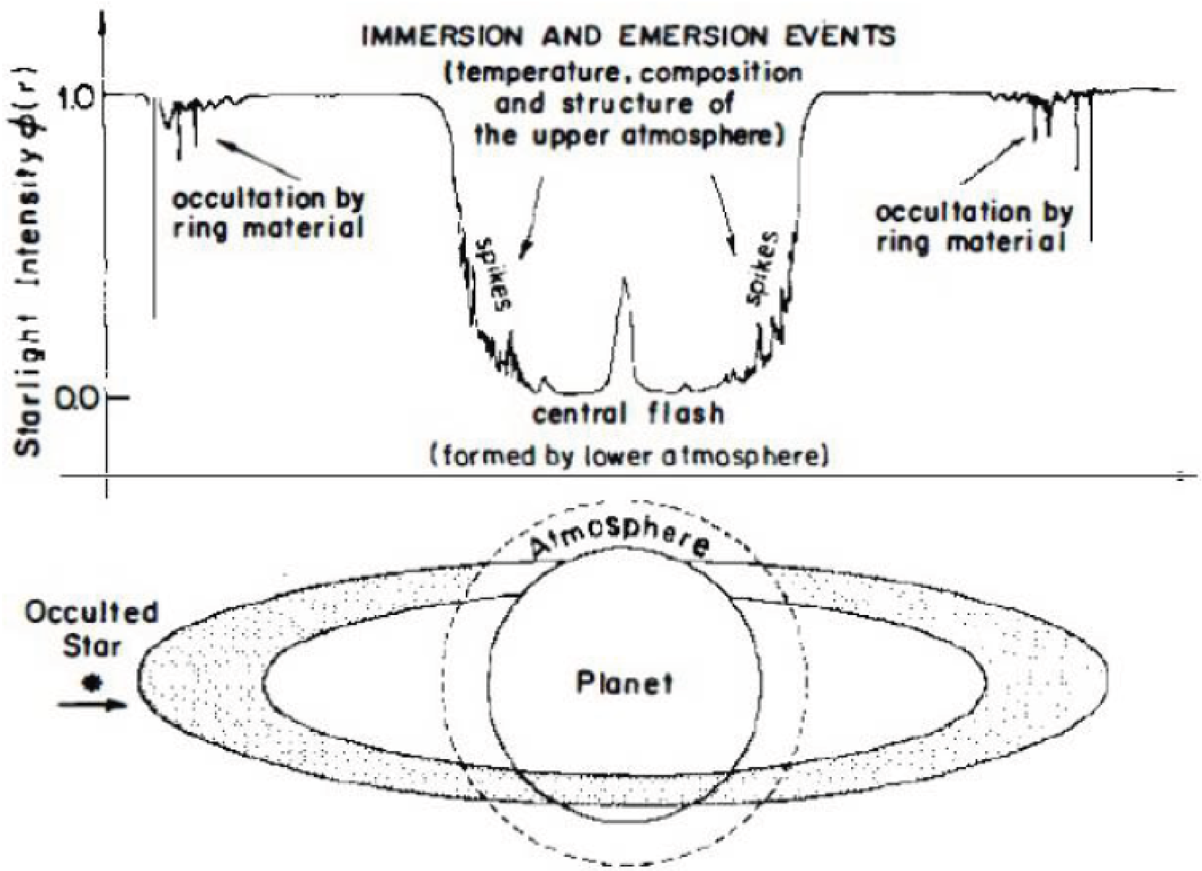
Goal

- Predict stellar occultation by irregular satellites to determine:
  - Size;
  - Shape;
  - Albedo;
  - Density, if mass known;
  - Characterize family of satellites.

Stellar Occultation



Elliot et al, 1979

Irregular Satellites

Table 1. Estimated diameter of the satellites and correspondent apparent diameter.

Satellite	Diameter of the satellites mas[a]	km	Ref.
Ananke	8	29	1
Carme	13	46	1
Elara	24	86	1
Himalia	41	$(150 \times 120) \pm 20^b$	2
Leda	5	20	1
Lysithea	10	36	1
Pasiphae	17	62	1
Sinope	10	37	1
Phoebe	32	212 ± 1.4^b	3

References: 1 – Rettig, Walsh & Consolmagno (2001); 2 – Porco et al. (2003); 3 – Thomas (2010).

Notes. [a]Using a mean distance from Jupiter of 5 au, from Saturn of 9 au and from Neptune of 30 au.

[b]From Cassini observations.

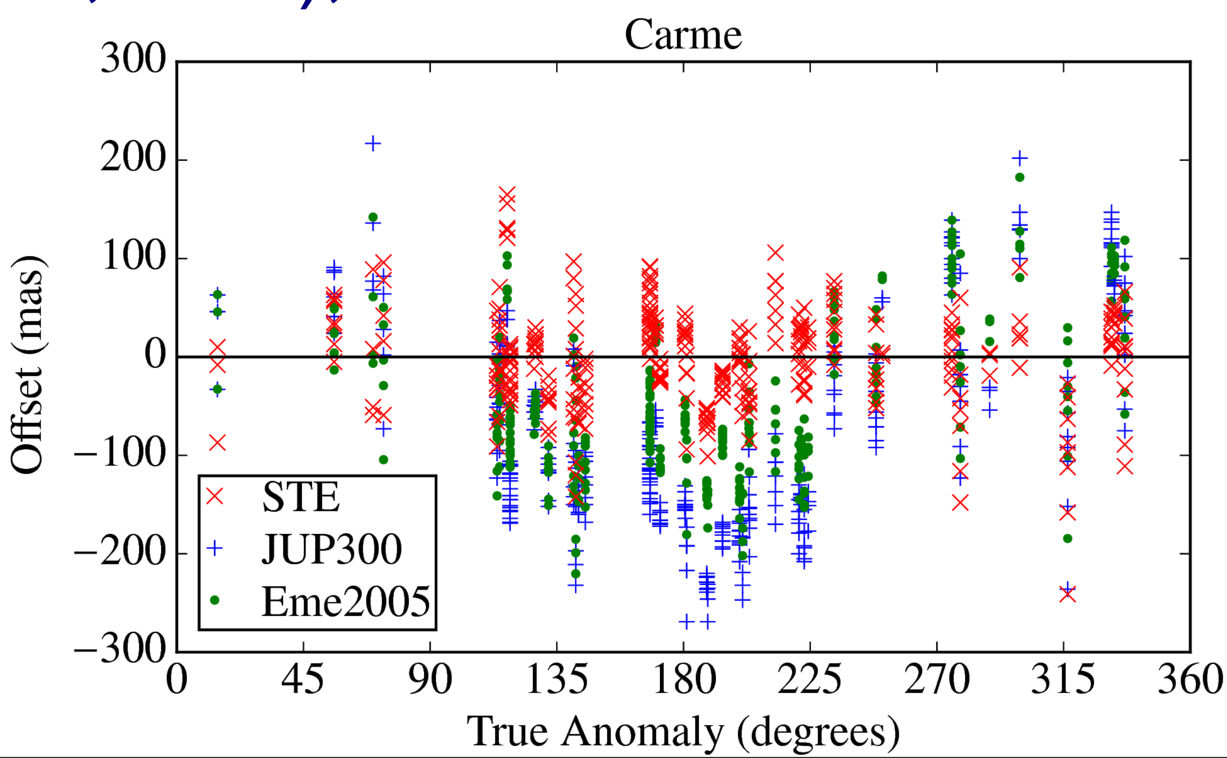
Gomes-Júnior et al. (2016)

Opportunity for Irregular Satellites

- Successful experience in stellar occultations by TNOs/Centaurs with Rio team;
- Saturn and Jupiter will cross the central side of the Galactic Plane in 2018 and 2019-2020, respectivelly;
- Release of the Gaia catalogue (DR1 in September 2016);
- Improvement of ephemeris using our positions (Gomes-Júnior, 2015).

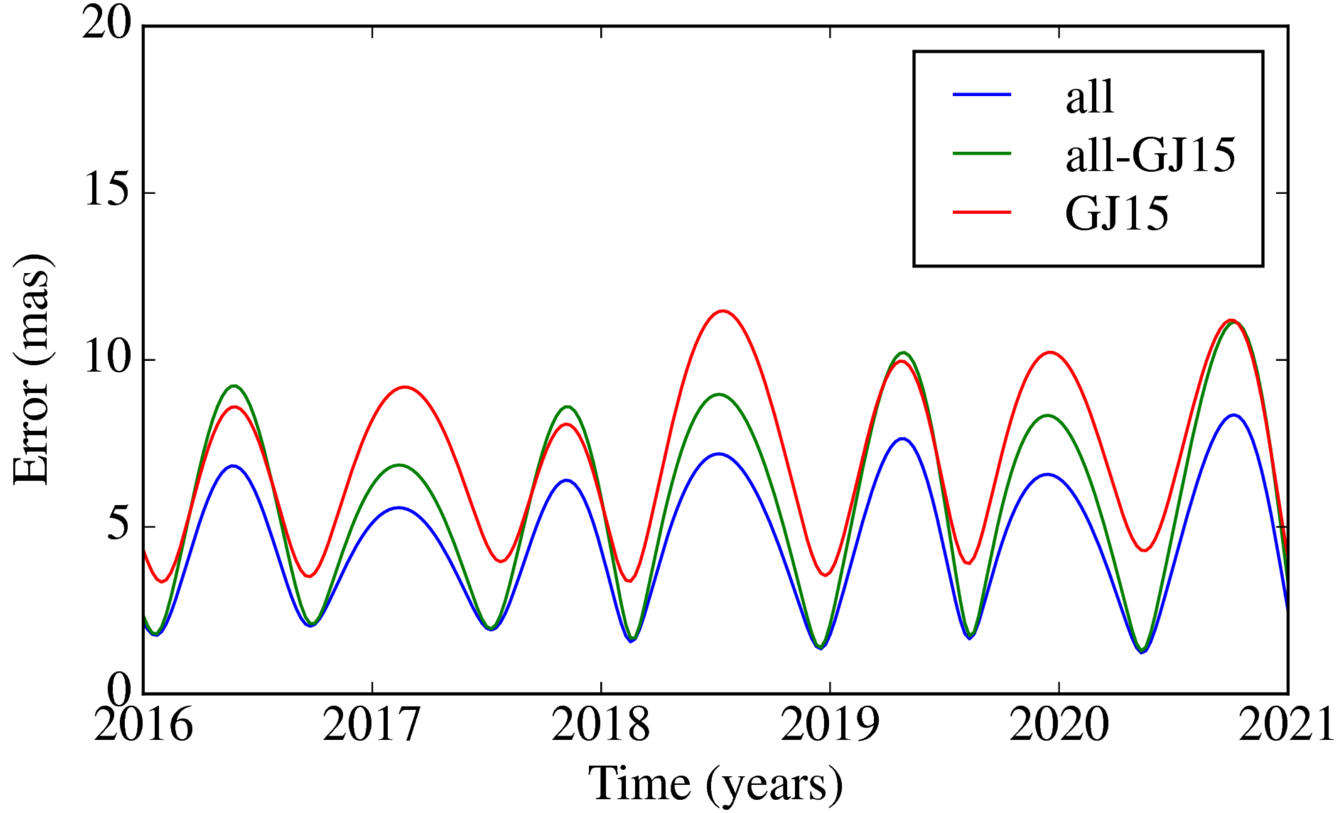
Special Tailored Ephemeris

- Ephemeris for the 8 major irregular satellites of Jupiter;
- Only using the positions of Gomes-Júnior et al. (2015, A&A);



Ephemeris of Phoebe

- Update the ephemeris of Desmars et al. (2013) using the position of Gomes-Júnior et al. (2015, A&A), +75% in the number of obs.



Prediction

- Code: PRAIA;
- Ephemeris: STE and Phoebe ephemeris;
- Star Catalogue: UCAC4;
- Number of occultations: 5442 from January 1st, 2016 up to December 31, 2020;
- 10% with stars brighter than R=14. Potentially observable by amateurs.
- 25% with stars brighter than R=15.

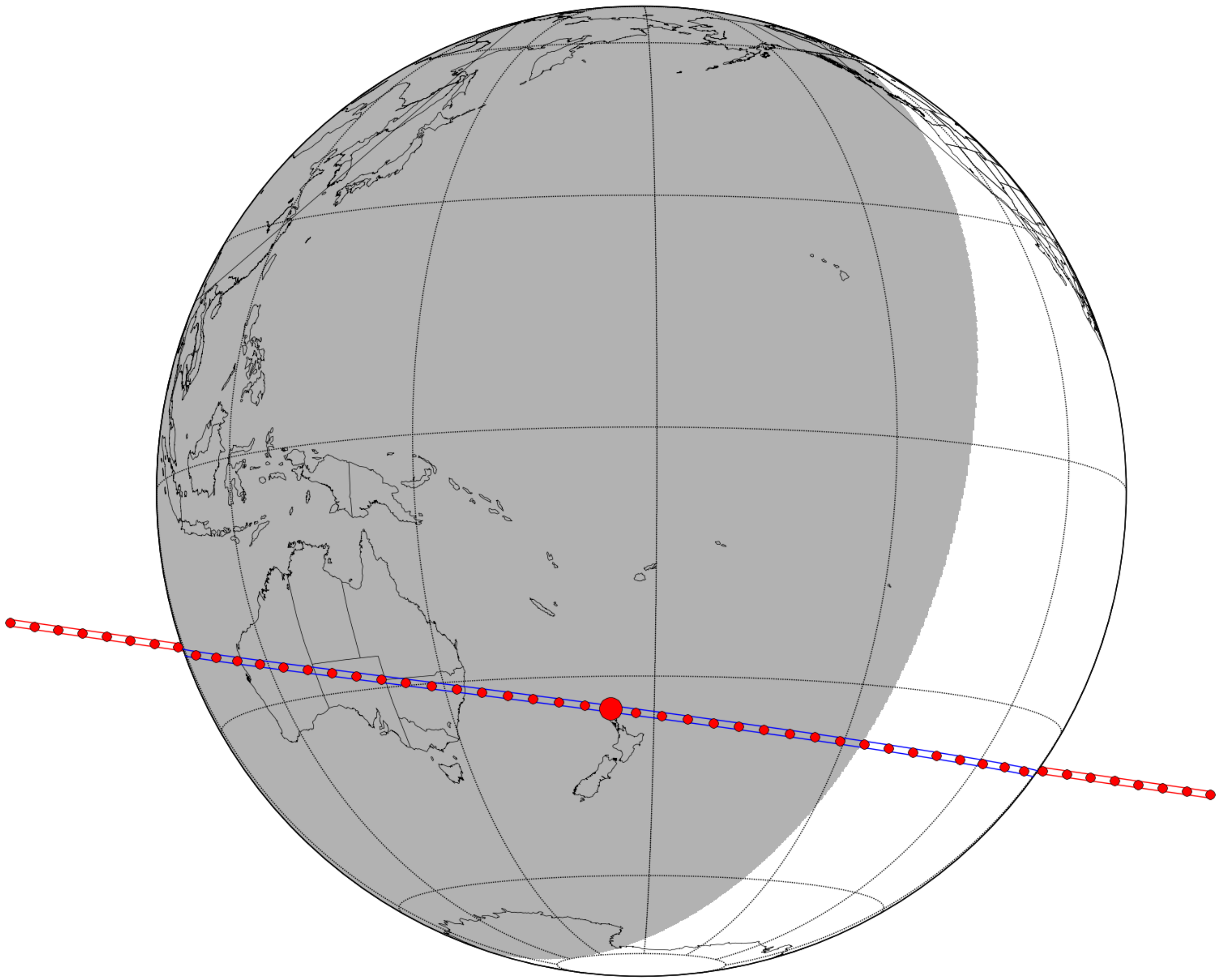
Occultations

Table 4. Number of stellar occultations for each satellite from 2016 January up to 2020 December.

Satellite	2016	2017	2018	2019	2020	Total
Ananke	12	16	49	359	187	623
Carme	20	14	30	369	220	653
Elara	14	16	33	305	193	561
Himalia	15	12	54	257	230	568
Leda	8	24	38	362	208	640
Lysithea	16	11	35	330	212	604
Pasiphae	20	19	44	362	206	651
Sinope	15	21	34	356	256	682
Phoebe	32	98	238	79	13	460

Elara – February 02, 2017

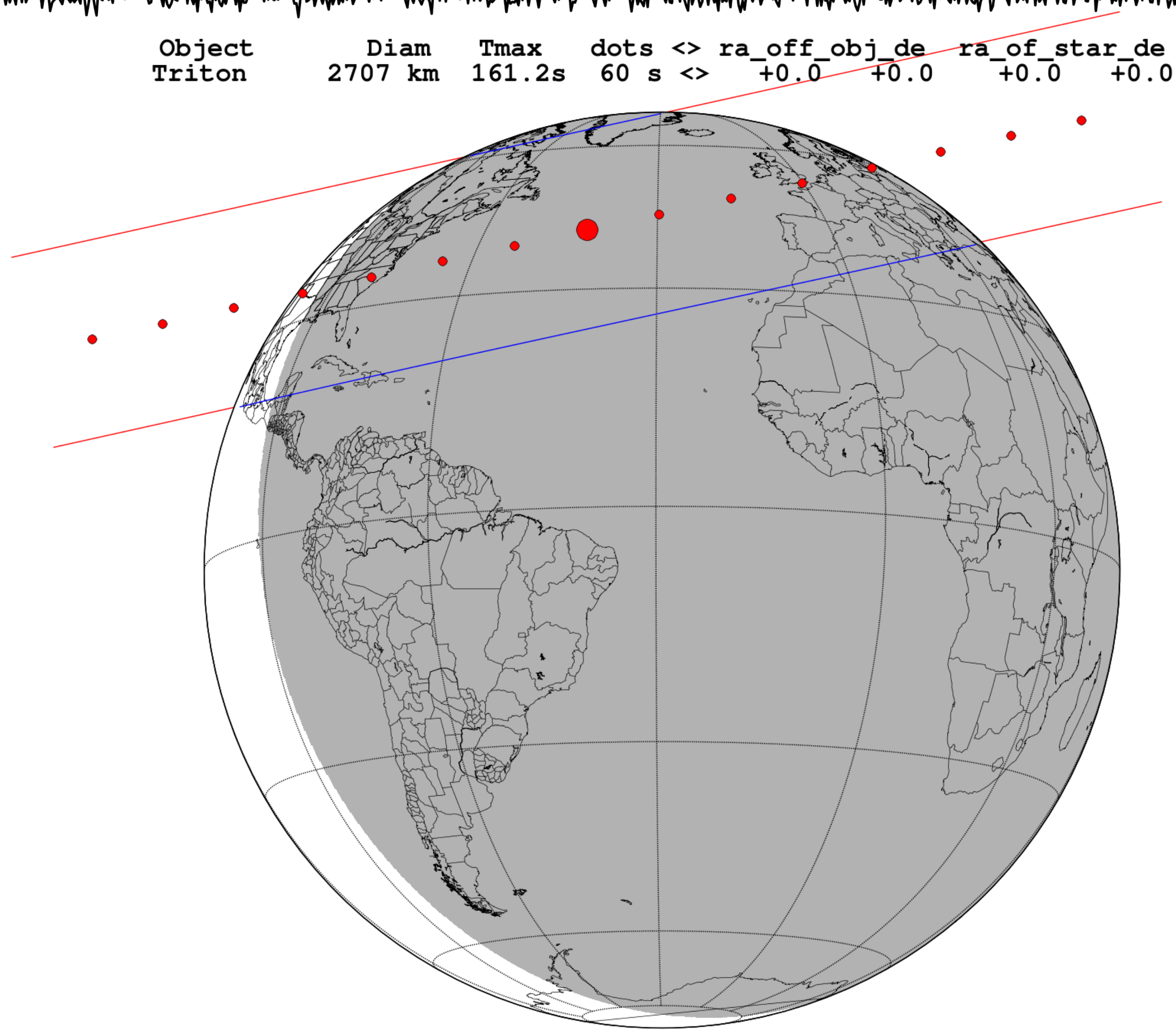
Object	Diam	Tmax	dots <>	ra_off_obj_de		ra_of_star_de	
Elara	86 km	16.2s	60 s <>	+0.0	+0.0	+0.0	+0.0



year-m-d	h:m:s UT	ra__dec__J2000__candidate	C/A	P/A	vel	Delta	R*	K*	long
2017-02-21	15:28:40.000	13 28 17.7167 -07 36 14.177	0.831	188.15	-5.31	4.79	12.4	-1.4	178

Triton – October 05, 2017

Object	Diam	Tmax	dots	<>	ra_off_obj_de		ra_of_star_de	
Triton	2707 km	161.2s	60 s	<>	+0.0	+0.0	+0.0	+0.0



year-m-d	h:m:s UT	ra__dec__J2000__candidate	C/A	P/A	vel	Delta	R*	K*	long
2017-10-05	23:51:53.000	22 54 18.4370 -08 00 08.339	0.230	347.51	-16.79	29.08	12.3	-0.2	331

Next Steps

- Re-reduce the observations with GAIA catalogue;
- Numerical Integration of the orbits of the Irregular Satellites using all positions available;
- Update occultation predictions using GAIA;
- Observe stellar occultations by these objects.

Thank You