Asteroid sizes constrained by thermophysical model and stellar occultations

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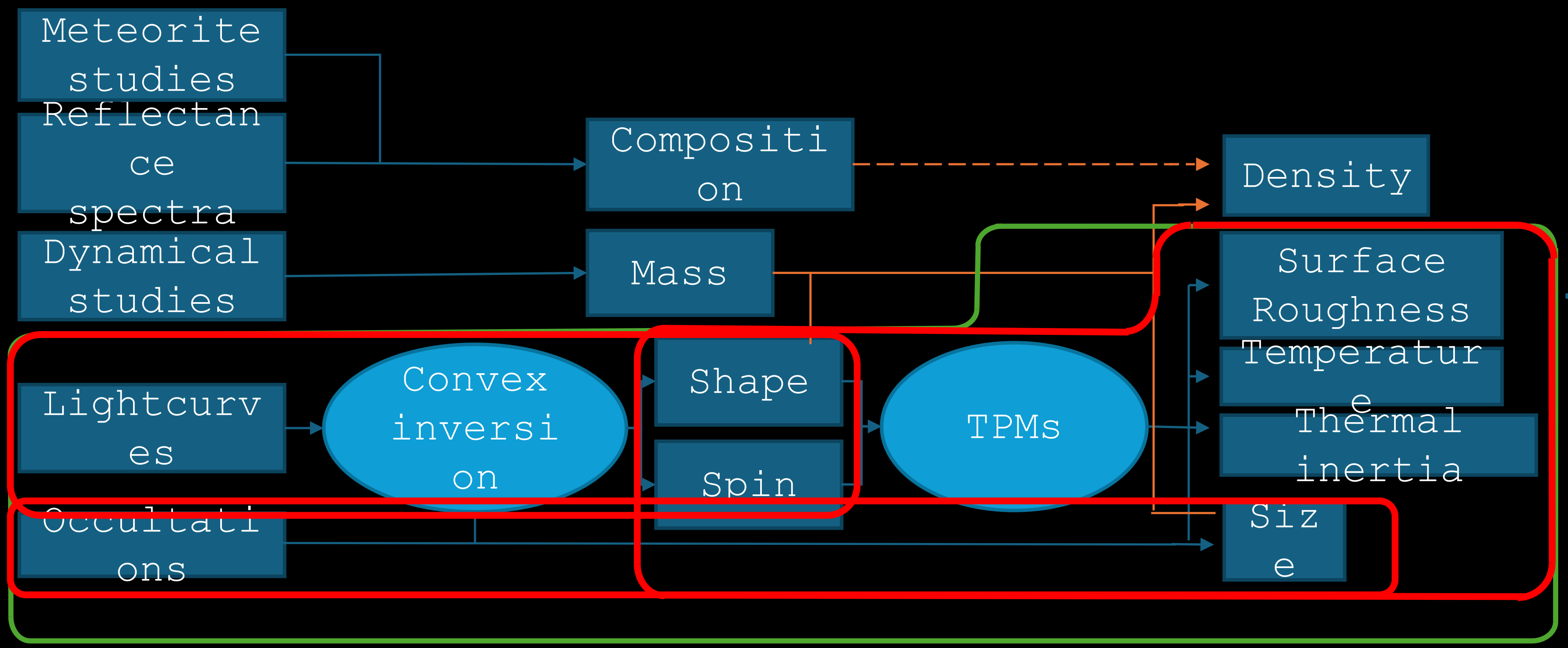
Methodology:



- Yarkovsky and YORP effects
- Planning and operation of asteroid space missions
- Geological information
- Solar System formation
- Planetary defense
- .
- .
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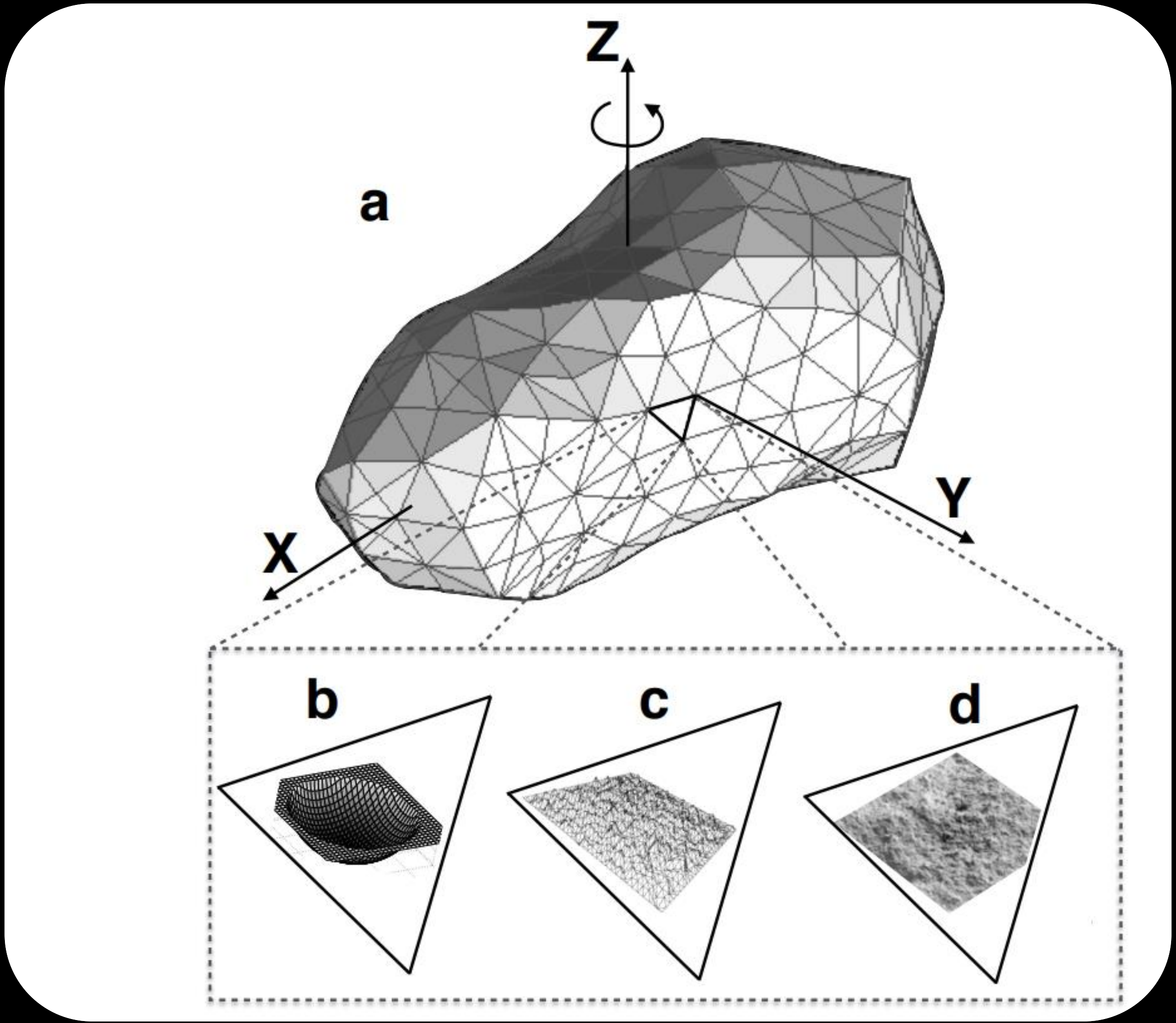
1. Constructing asteroid models based on dense lightcurves
2. Scaling the models with thermal data, to obtain precise sizes
3. Scaling the models with stellar occultations
4. Comparing sizes from both techniques and from the literature

Convex Inversion Thermophysical Model (CITPM) :



(Delbo et al. 2015)

Convex Inversion *(Kaasalainen & Torppa, 2001; Kaasalainen et al., 2001)*

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Thermo-Physical Model (TPM) *(Lagerros et al. 1996; Lagerros et al. 1997; Lagerros et al. 1998)*

$$\chi^2_{tot} = \chi^2_{visible} + \lambda_{ir} \times \chi^2_{ir}$$

Data set:

Target	Taxon.	N_{lc}	N_{app}	N_{IR}	N_{WISE}	N_{occ} (N_{pos})
(215) Oenone	S	78	8	53	22	1(2)
(279) Thule	X	107	13	33	15	3(5, 2, 4)
(357) Ninina	CX	89	7	38	10	4(7, 2, 4, 7)
(366) Vincentina	Ch	69	9	67	21	3(6, 6, 2)
(373) Melusina	C	31	6	40	11	1(2)
(395) Delia	Ch	68	7	20	11	3(3, 2, 2)
(429) Lotis	C	79	8	41	11	1(2)
(527) Euryanthe	Cb	90	6	35	19	2(6, 5)
(541) Deborah	B	44	6	48	30	3(2, 4, 6)
(672) Astarte	S	62	8	24	16	1(4)
(814) Tauris	C	101	11	19	8	1(5)
(859) Bouzareah	X	49	7	39	12	3(2, 3, 4)
(907) Rhoda	Xk	92	9	46	22	1(2)
(931) Whittemora	M	60	9	49	24	3(3, 2, 2)
(1062) Ljuba	C	132	9	27	14	2(2, 2)

Notes. 'Taxon.' refers to the taxonomic type. N_{lc} is the number of dense light curves for each target registered at N_{app} apparitions, N_{IR} is the number of all infrared data points, and N_{WISE} is the number of data points obtained by WISE spacecraft. N_{occ} represents the number of stellar occultation events, with the number of positive chords for each event shown in parentheses. Taxonomic types come from Tholen (1984), Bus & Binzel (2002) and from Vereš et al. (2015).

Choukroun et al. (2025)

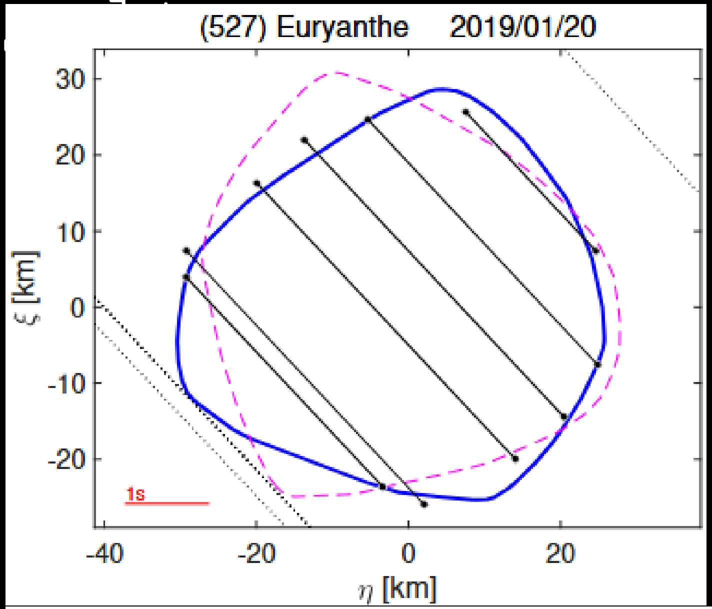
Diameters from the li...

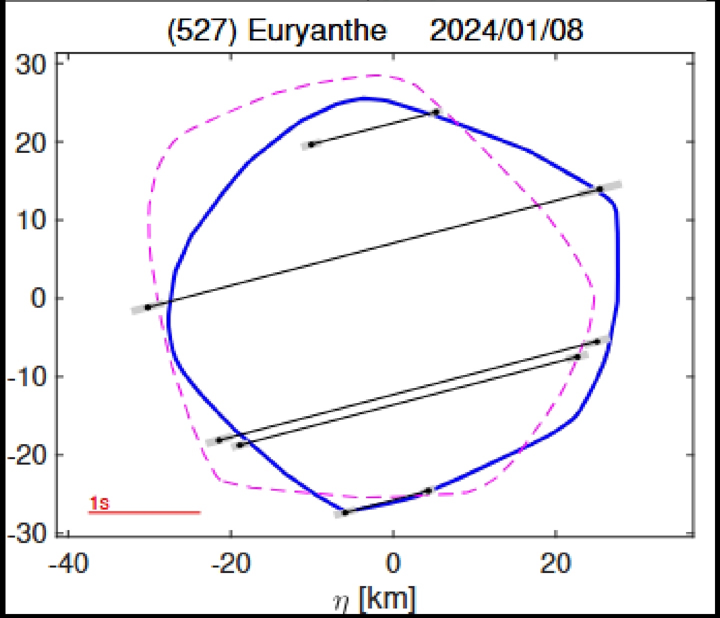
Asteroid	D_{min} (km)	D_{min} reference	D_{max} (km)	D_{max} reference	$\overline{D}$ (km)
(215) Oenone	35.21 ± 0.4	[1]	43.69 ± 4.370	[2]	41.82 ± 0.10
(279) Thule	113.04 ± 3.11	[3]	136.78 ± 7.105	[4]	122.62 ± 2.05
(357) Ninina	92.54 ± 3.015	[4]	124.11 ± 0.86	[5]	113.77 ± 0.61
(366) Vincentina	83.84 ± 8.38	[2]	98.25 ± 4.638	[4]	86.65 ± 0.30
(373) Melusina	84.55 ± 8.45	[2]	107.74 ± 5.815	[4]	95.94 ± 0.61
(395) Delia	44.19 ± 0.45	[5]	61.49 ± 0.7	[5]	50.16 ± 0.34
(429) Lotis	54.2 ± 4.56	[6]	89.69 ± 38.25	[5]	69.79 ± 0.68
(527) Euryanthe	48.55 ± 13.62	[7]	58.56 ± 0.62	[5]	53.99 ± 0.27
(541) Deborah	49.04 ± 17.985	[8]	65.60 ± 3.801	[4]	55.42 ± 0.31
(672) Astarte	27.49 ± 2.75	[2]	35.58 ± 0.495	[9]	33.37 ± 0.33
(814) Tauris	98.77 ± 33.9	[6]	122.26 ± 1.819	[4]	111.9 ± 0.97
(859) Bouzareah	65.21 ± 2.758	[4]	86.02 ± 1	[5]	70.28 ± 0.39
(907) Rhoda	62.73 ± 1.7	[10]	98.01 ± 32.58	[11]	80.91 ± 0.30
(931) Whittemora	40.62 ± 2.02	[5]	63.51 ± 11.434	[4]	50.1 ± 0.42
(1062) Ljuba	51.02 ± 0.887	[9]	63.16 ± 12.63	[2]	54.91 ± 0.52

Notes. Data extracted from the MP3C database (https://mp3c.oca.eu/). D_{min} and D_{max} are the minimum and the maximum published value, respectively, and $\overline{D}$ is the error-weighted mean diameter from all the literature values computed as follows: $\overline{D} = \sum(\frac{D_i}{\sigma_i^2}) / \sum(\frac{1}{\sigma_i^2})$. The uncertainties were evaluated with: $\sigma_{\overline{D}} = \sqrt{1/\sum(\frac{1}{\sigma_i^2})}$. References: [1] Masiero et al. (2014), [2] Alí-Lagoa et al. (2018), [3] Usui et al. (2011), [4] Ryan & Woodward (2010), [5] Masiero et al. (2012), [6] Nugent et al. (2016), [7] Masiero et al. (2020), [8] Masiero et al. (2017), [9] Masiero et al. (2011), [10] Tedesco et al. (2002), [11] Masiero et al. (2021).

Choukroun et al. (2025)

Occultation re



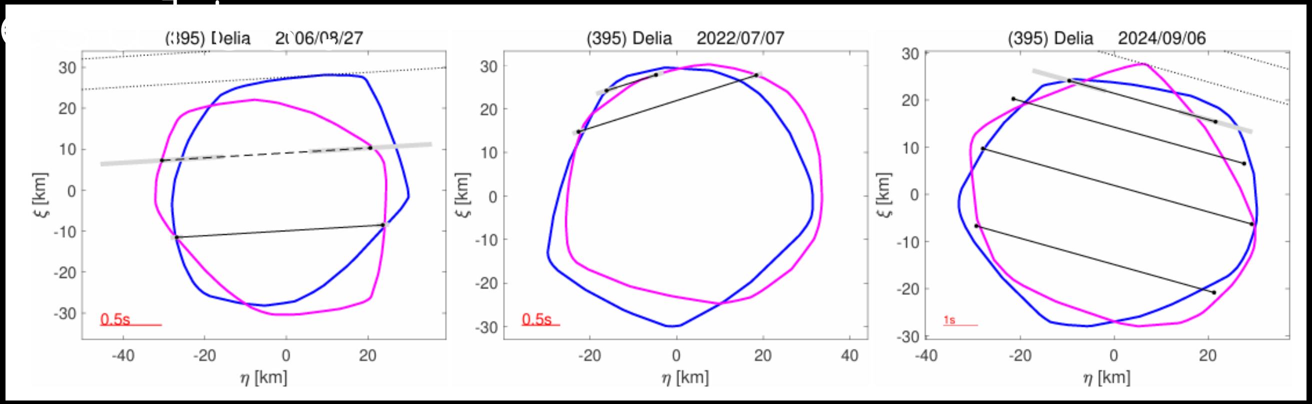


Target	Spin solution	D (km)	D RMS (km)
(215) Oenone	1	46 ± 1	1
	2	48 ± 1	1
(279) Thule	1	115 ± 12	12
	2	119 ± 13	13
(357) Ninina	**1**	$\mathbf{97^{+7}_{-8}}$	**6**
	2	113 ± 11	11
(366) Vincentina	1	92 ± 6	5
	2	87^{+14}_{-6}	6
(373) Melusina	1	99 ± 8	8
	2	$\mathbf{103^{+6}_{-3}}$	**3**
(395) Delia	1	56 ± 3	3
	2	55 ± 3	3
(429) Lotis	1	58 ± 9	9
	2	62 ± 1	1
(527) Euryanthe	1	53 ± 6	6
	2	**52 ± 2**	**2**
(541) Deborah	1	60 ± 5	5
	2	**57 ± 2**	**2**
(672) Astarte	1	28.5 ± 1.3	1.3
	2	32.3 ± 1.0	0.9
(814) Tauris	1	112 ± 9	9
	2	113 ± 9	9
(859) Bouzareah	1	66 ± 6	6
	2	67 ± 6	6
(907) Rhoda	1	63 ± 2	2
	2	63 ± 1	1
(931) Whittemora	1	49 ± 5	5
	2	**54 ± 2**	**2**
(1062) Ljuba	1	41 ± 4	4
	2	**44 ± 4**	**4**

Notes. For each target and pole solution presented in Table 4, the diameter of the equivalent volume sphere is given, together with its best estimate of uncertainty, influenced by the uncertainty of both occultation timings and the shape model itself. The last column contains the formal RMS uncertainty of the occultation fit only (see text in Section 4.2 for details). Solutions preferred by occultations are marked with boldface.

Choukroun et al. (2025)

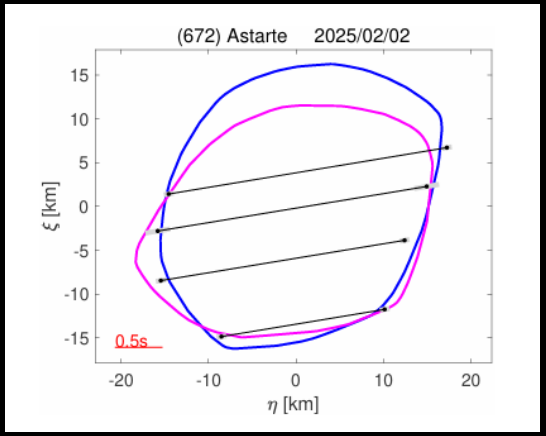
Occultation re



Occultation fits for asteroid (395) Delia

Diameter from pole solution 1 : 56 ± 3

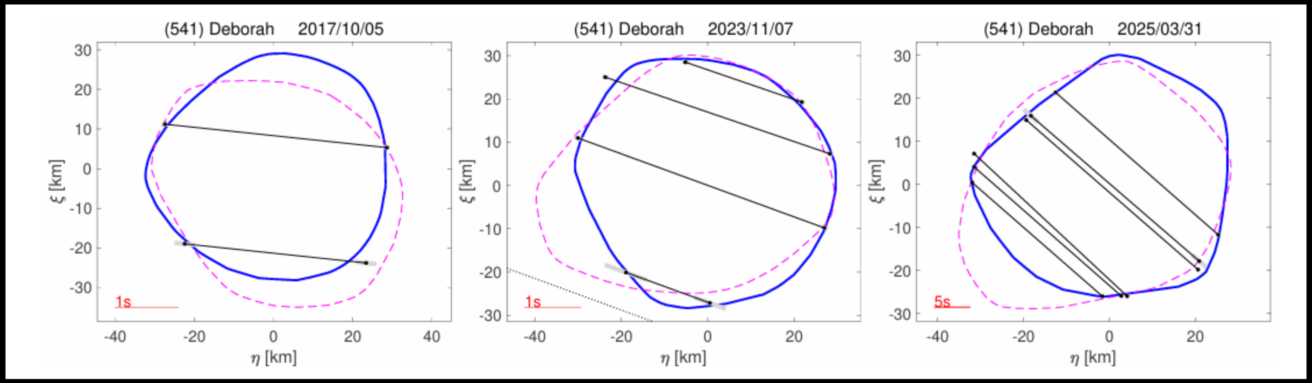
2 : 53 ± 3



Occultation fits for asteroid (672) A

Diameter from pole solution 1 : 28.5 ± 1.3

2 : 32.3 ± 1



Occultation fits for asteroid (541) Deborah

Diameter from pole solution 2 : 57 ± 2

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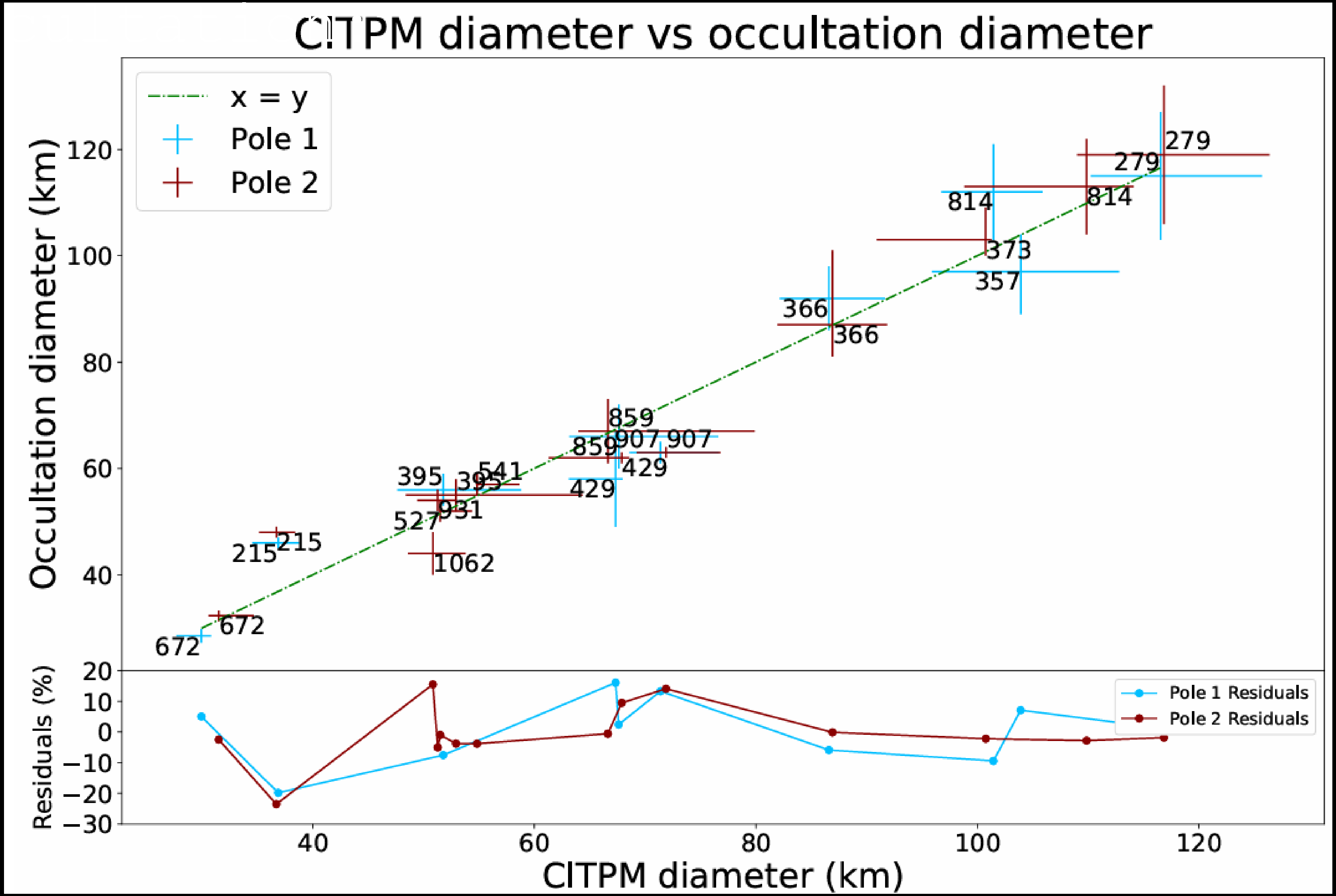
CITPM vs Oc



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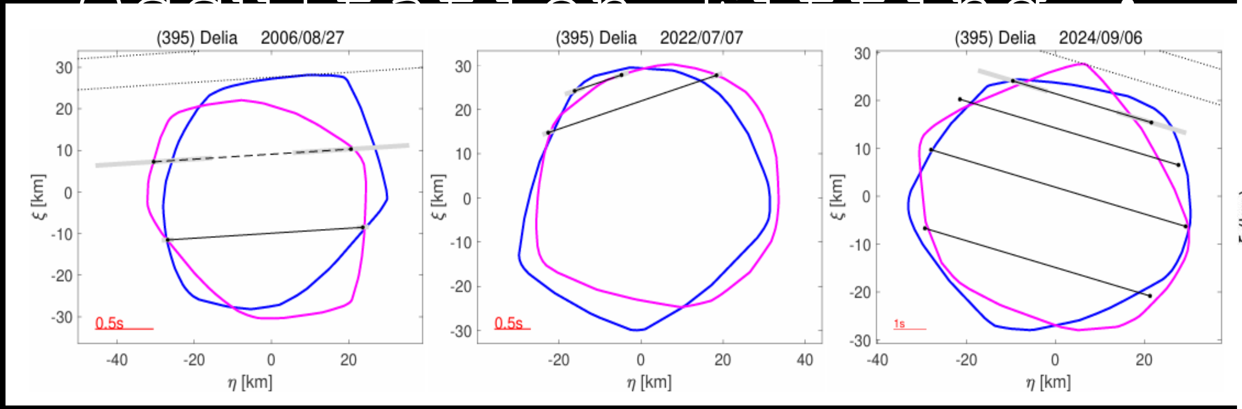
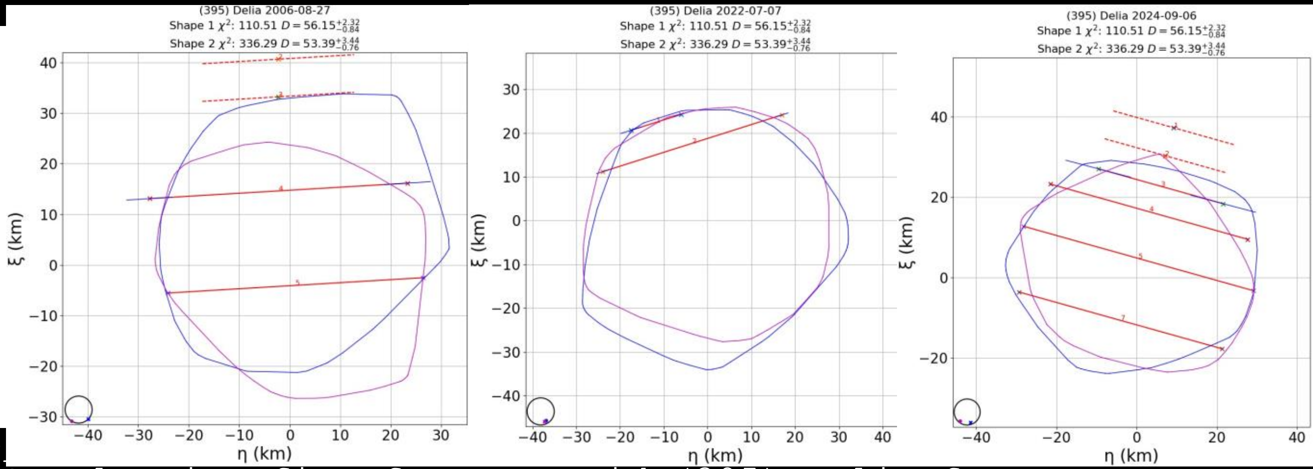
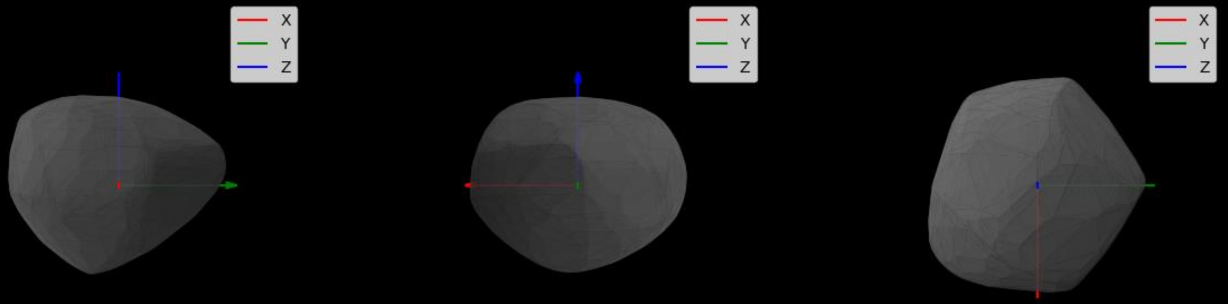
Open-Source Software for Stellar Occultation Fitting :



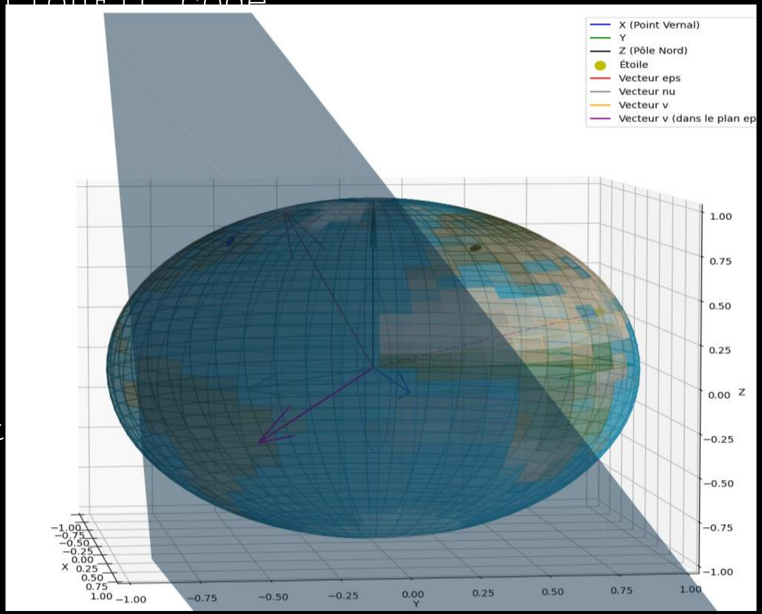
Occultation fits for asteroid (395) Delia from *Choukrou*
al. (2025)



Occultation fits for asteroid (395) Delia from
occultationFit code



Model of pole 1 of asteroid (395) Delia from occultationFit
code



Reconstruction of the observation 2024/09/06 of (39

My github profil : antoinech13

Conclusions:

Take-home points:

- Only high-quality data was used (dense lightcurves, WISE data, no saturated or partially saturated data points…).

- Two techniques for shape modelling (convex inversion and CITPM) and for scaling (CITPM and occultations) were used.

- Modelled targets had not been well studied before.

- Accurate and well-constrained spin solutions were found, as well as good shape model.

- Precise and well-constrained size values were determined using CITPM, in agreement with occultation results.

- Results available in: *Asteroid sizes determined with a thermophysical model and stellar occultations – Choukroun et al. (2025)*