GAIA MISSION: THE TRUE TIME SAVER FOR ASTEROIDS SHAPE MODELLING AND SPECTRAL CLASSIFICATION

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The Milky Way Revealed by Gaia: The Next Frontier
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THE IMPORTANCE OF STUDYING ASTEROIDS

- **Carriers of primordial information**
- **Prevention of possible future collisions**
- **Containing elements that are deficit on the Earth**
- **Understanding the dynamic of the Solar System**
- **Collecting information about the history, evolution and future of our planetary system**

THE SHAPE OF THE ASTEROID

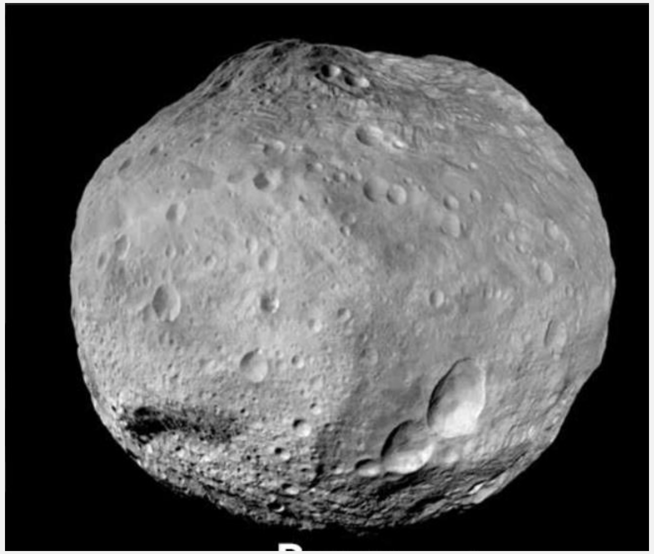


Fig. 4 Vesta

- **Basic representation of the shape: Triaxial ellipsoid shape with axis a, b, and c**
- **a>b>c**
- **Rotation about the smallest axis**

Fig. 433 Eros

Statistics

- **Smaller objects reach more elongated shapes than the large ones**
- **The shape can depend from the type of the asteroid: S-type are more elongated than C- and D-type (Torppa J., 2008)**
- **The period of rotation influence on the shape**
- **Lack of data for asteroids smaller than 30 km in diameter**

SPARSE DATA

- The photometric sparse data are side product from astronomical data bases or space mission
- Sparse data are rare in time (only one or max 5 photometric points during one observational night
- **GAIA** sparse data are more accurate compared with the ground based sparse data
- These data increase the distribution of the PAB longitude and latitude, and gives as information from parts of the asteroid surface, we have never observed

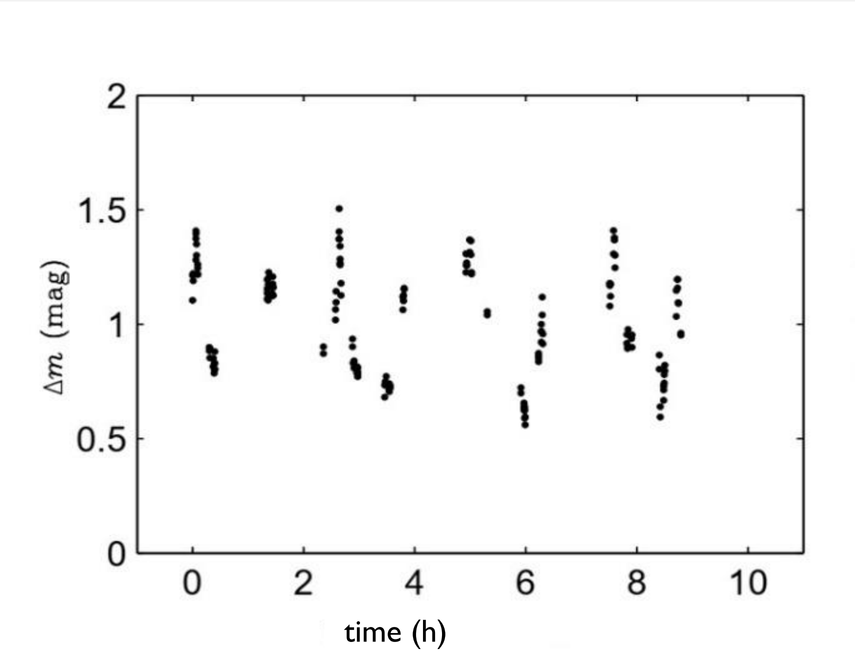


Fig. Sparse data lightcurve

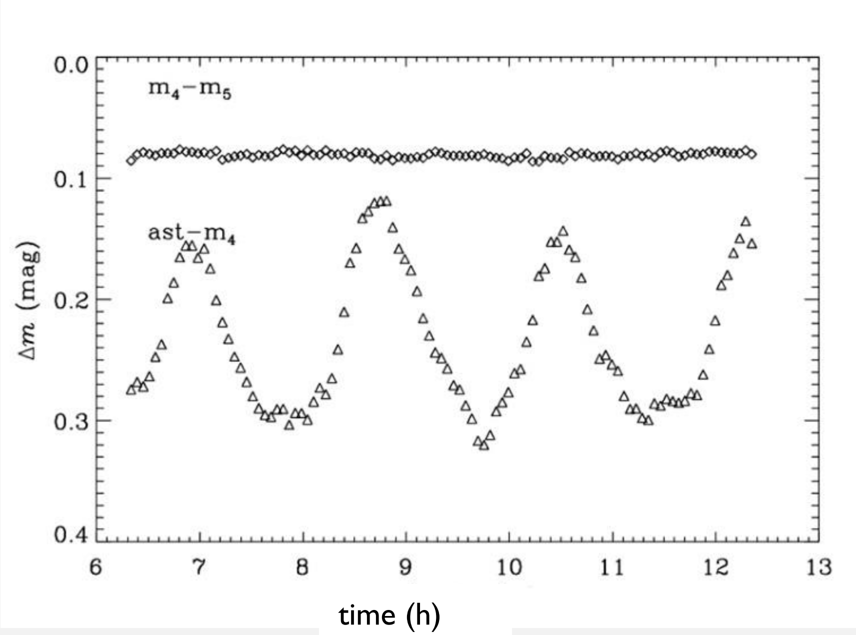
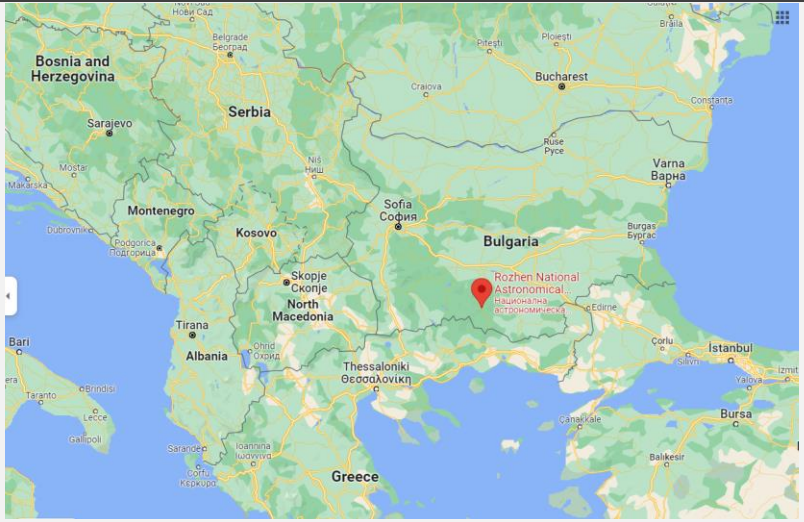


Fig. Dense data lightcurve

NAO ROZHEN



Telescopes:

- 2 m Ritchey-Chretien-Coude (RCC) telescope
- 50/70 cm Schmidt telescope
- 60 cm Cassegrain telescope
- 1.5 m AZ 1500 telescope
- 15 cm coronagraph
- Several smaller telescopes for amateurs/visitors

THE MODEL OF 901 BRUNSIA

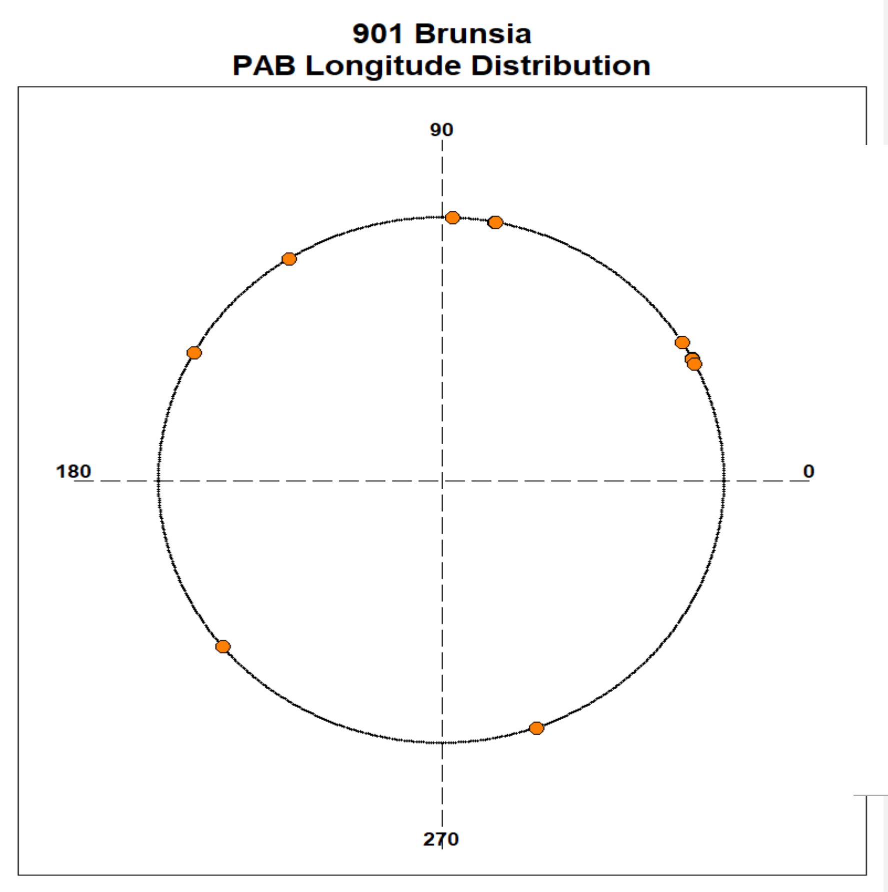
- Flora family member
- Discovered in 1918
- Period of rotation 3.1363 h
- S spectral type

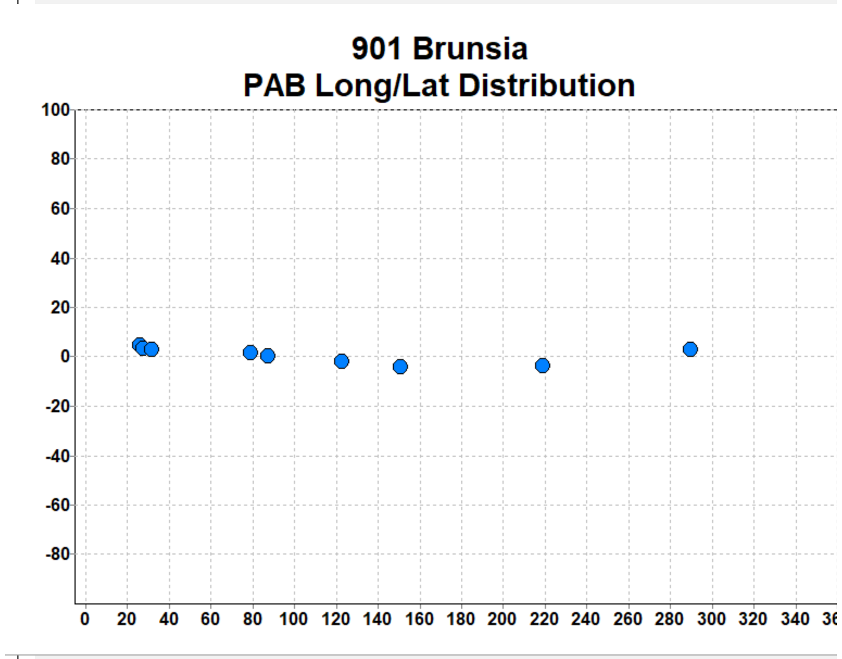
Aspect data for 901 Brunsia

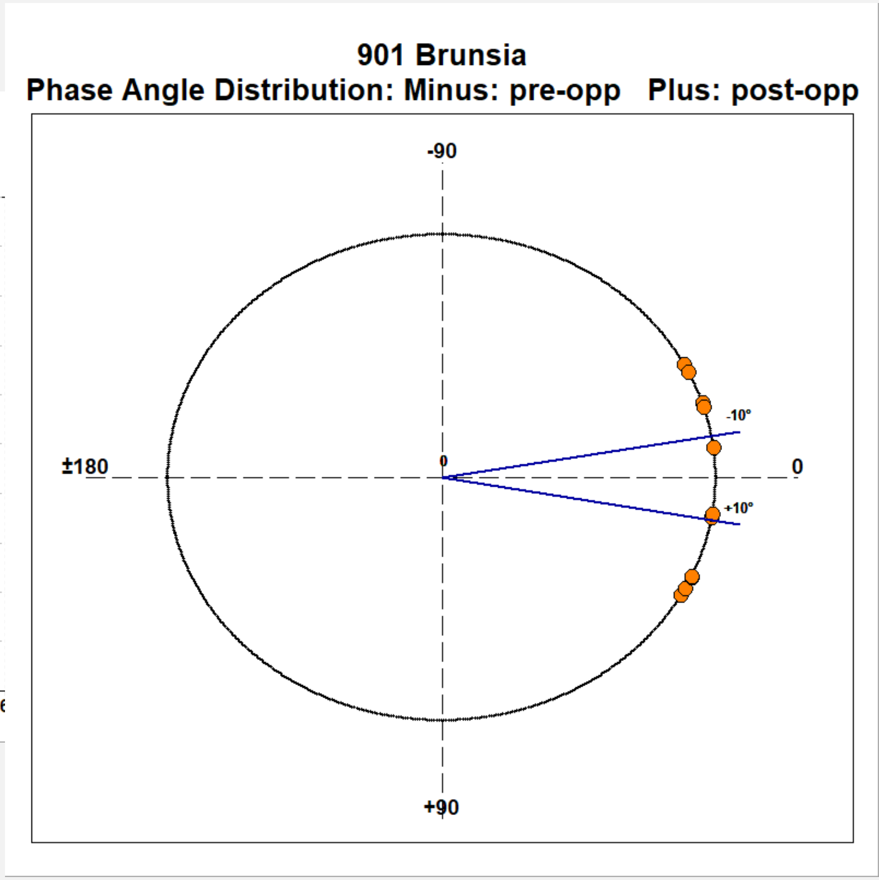
Asteroid	Date (UT)	*r* (AU)	*Δ* (AU)	Phase angle (°)	*λ* (°)	*β* (°)
901 Brunsia	2011 Dec 01.79	1.9415	1.1878	24.16	15.62	4.03
	2011 Dec 16.77	1.9780	1.3641	27.08	18.28	3.22
	2013 March 10.96	2.7156	1.7787	8.58	146.92	-4.95
	2013 March 13.0	2.7158	1.7901	9.41	146.47	-4.93
	2014 Aug 26.85	1.7715	1.0175	29.02	275.34	3.77
	2015 Dec 14.96	2.5552	1.7964	16.84	131.32	-2.38
	2017 March 21.06	2.4070	1.6223	17.87	228.34	-4.19
	2018 Oct 03.02	2.1300	1.7705	27.83	93.26	1.42
	2018 Dec 07.94	2.2980	1.3330	6.589	91.22	0.07
	2021 Sep 11.066	1.810	1.000	25.69	39.47	5.93

THE MODEL OF 901 BRUNSIA (DENSE LC)

Distribution of the phase angle and PAB longitude and latitude at the time of our observations

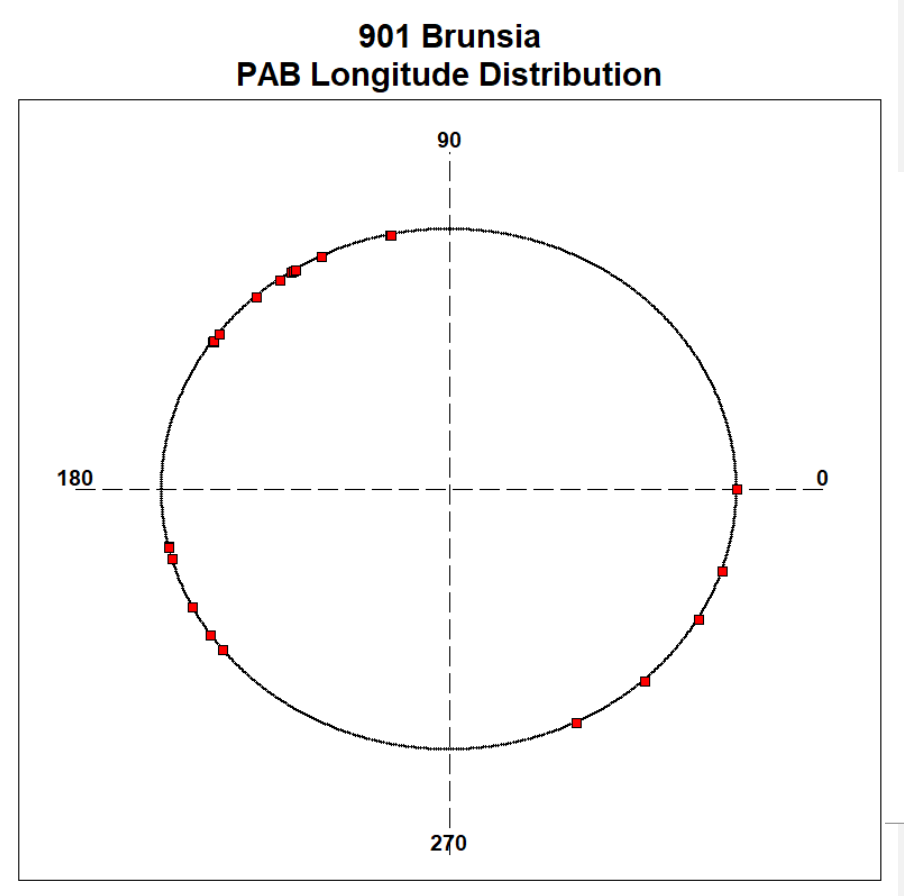


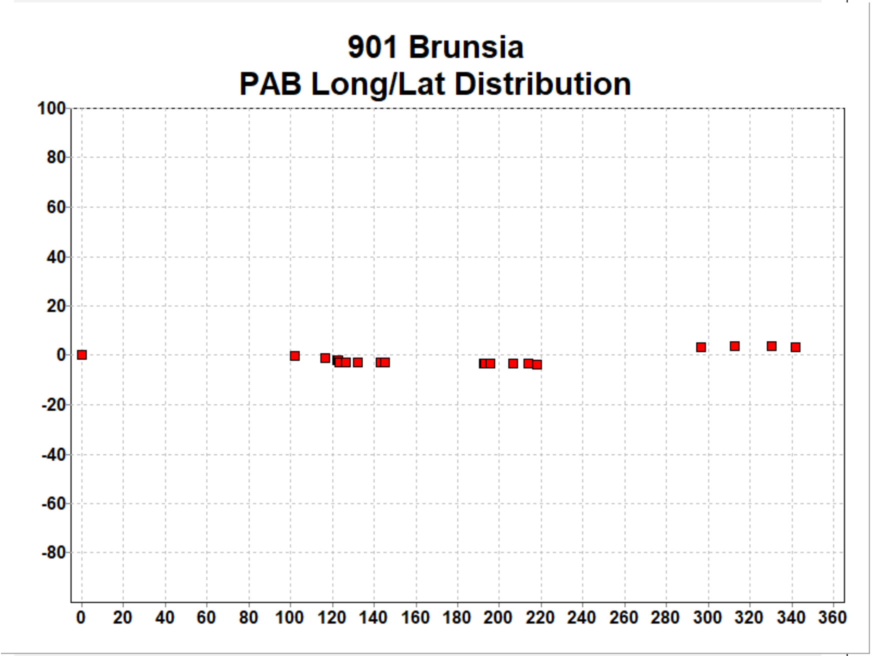


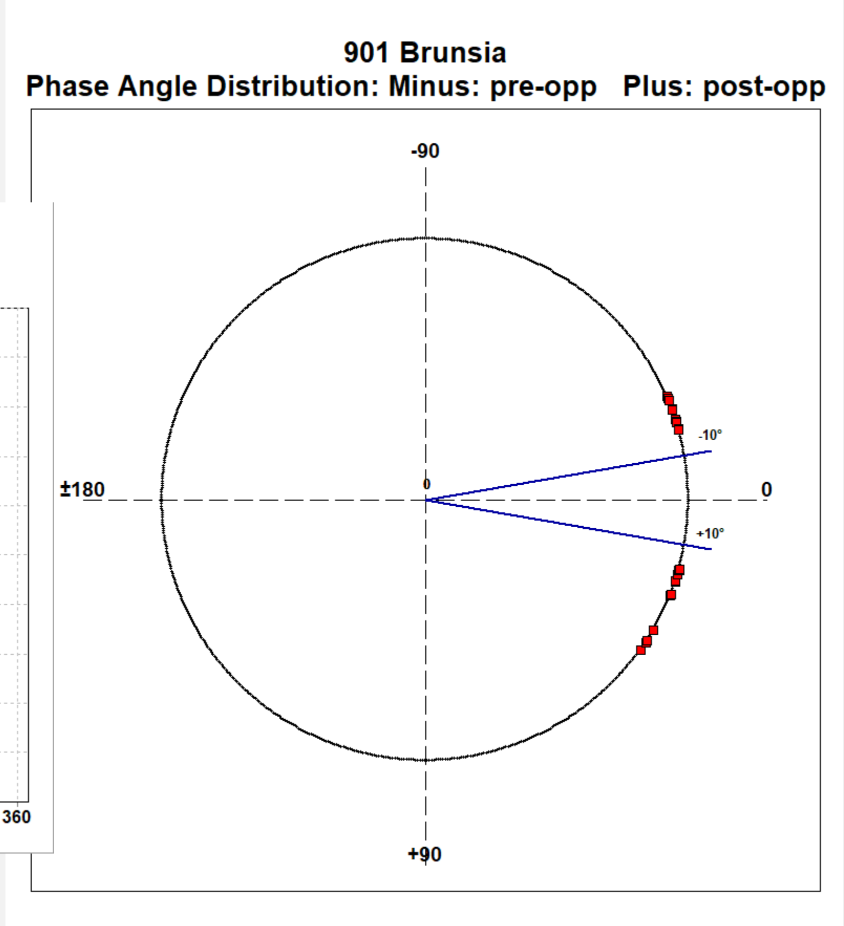


THE MODEL OF 901 BRUNSIA (GAIA DR3)

Distribution of the phase angle and PAB longitude and latitude from Gaia DR3

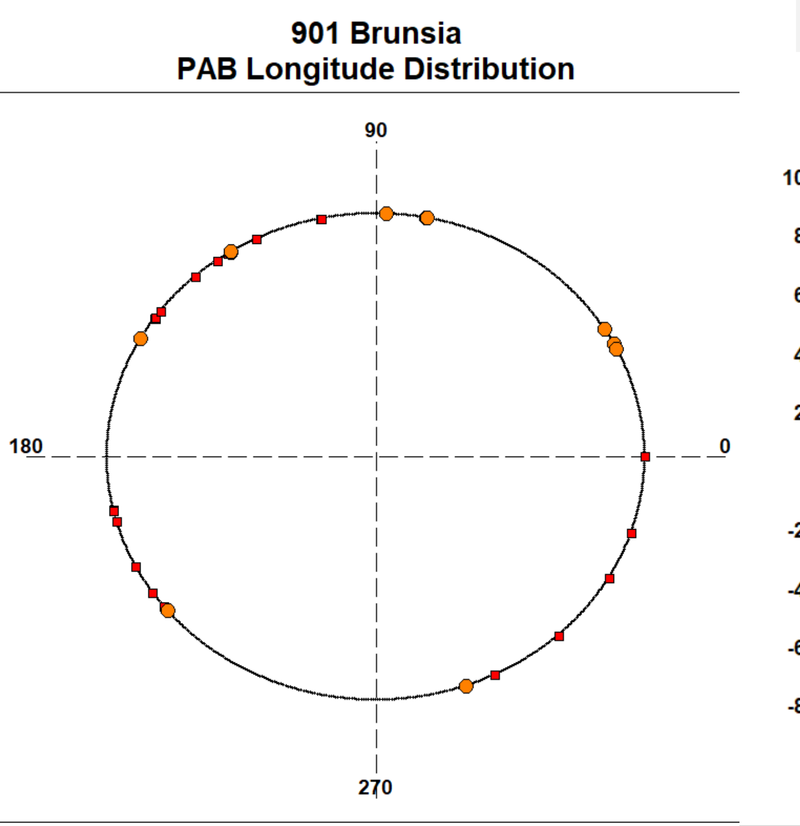


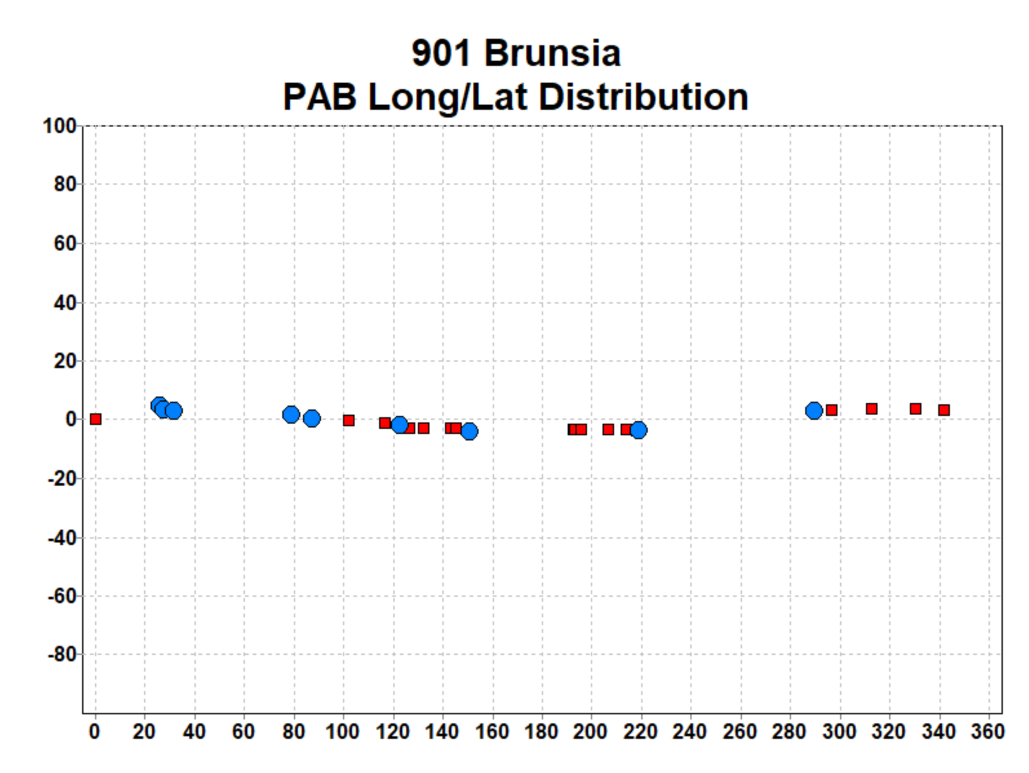


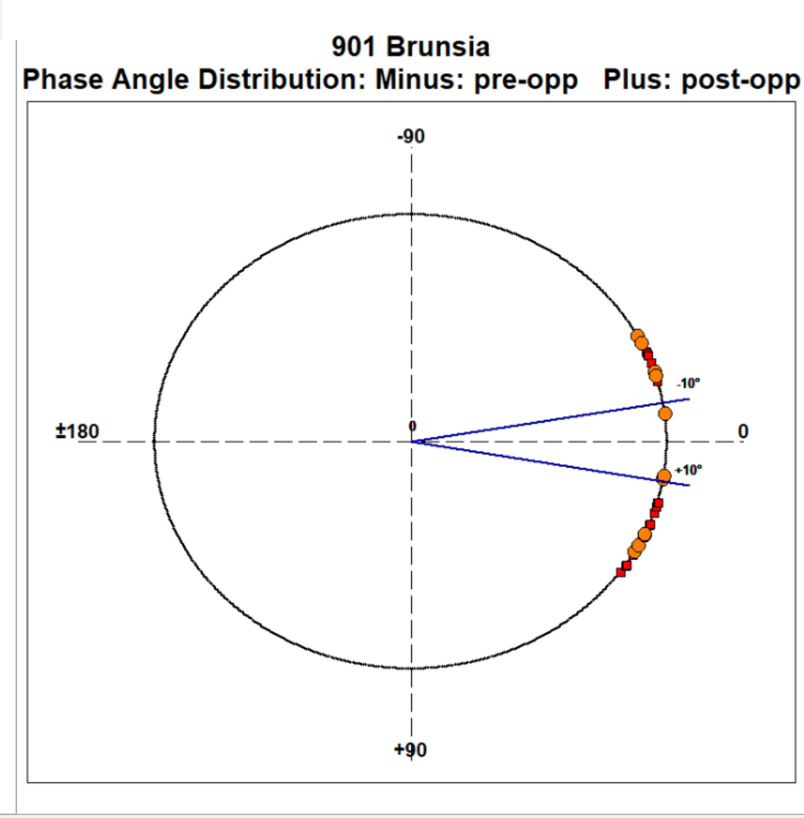


THE MODEL OF 901 BRUNSIA(COMBINATION OF DENSE AND SPARSE DATA

Distribution of the phase angle and PAB longitude and latitude from our dense observations (orange and blue points) and from Gaia DR3 (red points)



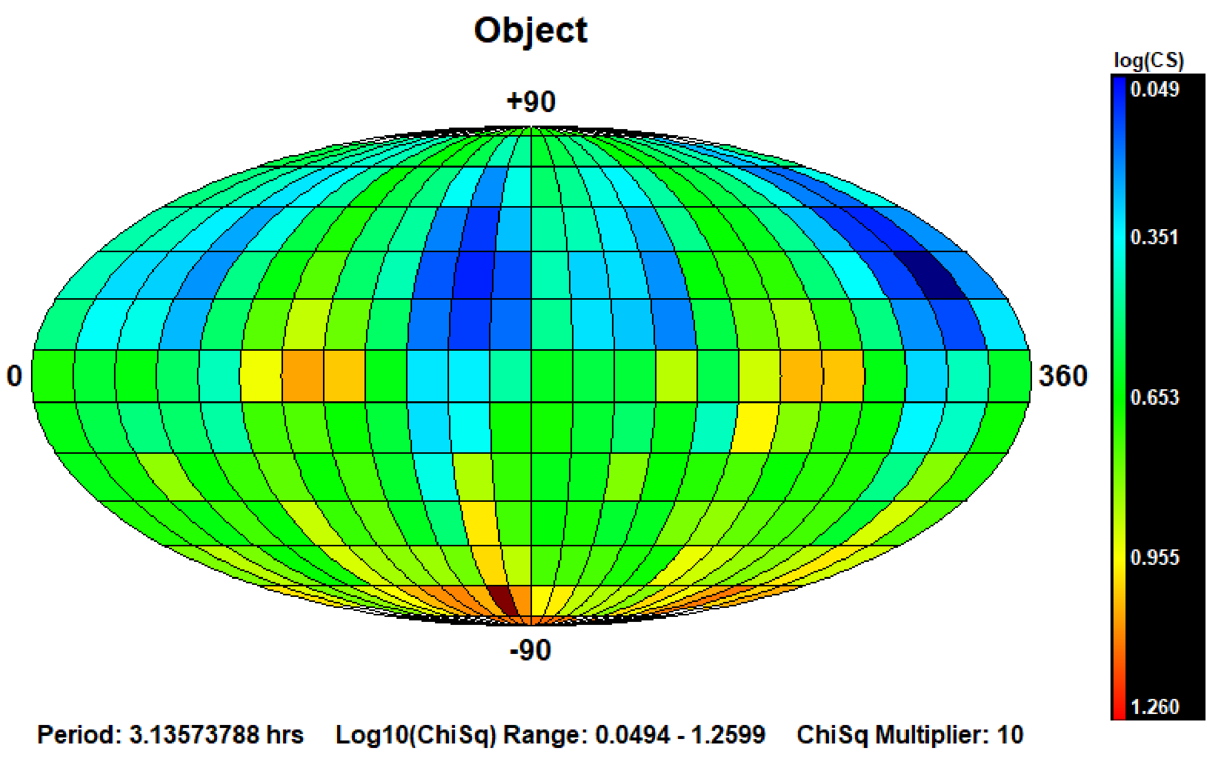


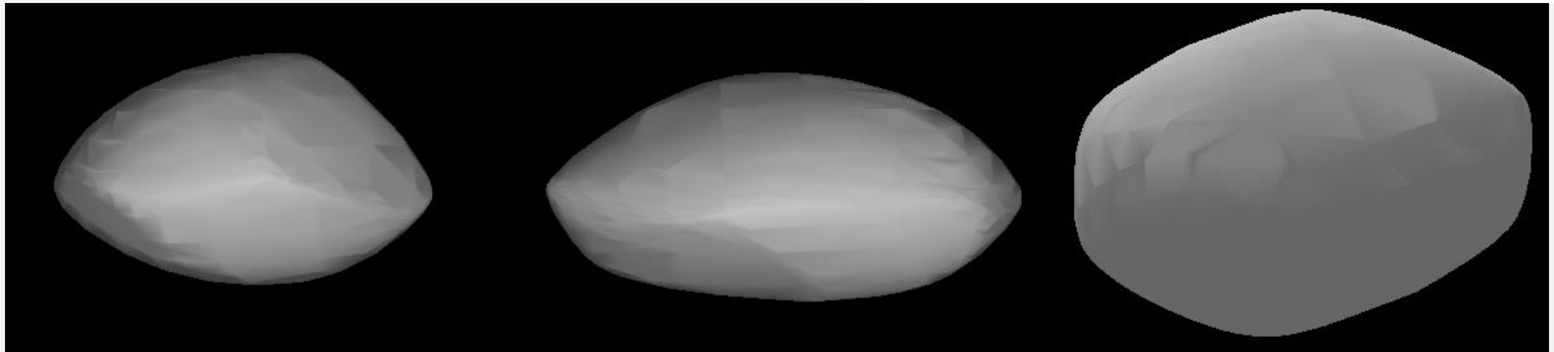


THE MODEL OF 901 BRUNSIA

The first solution for the model of 901 Brunsia

- The spheres with the possible solution. The blue regions indicates the solutions with the smallest χ^2
- Only dense data were used
- Extensive possibilities for the results for the model of the asteroid leading to greater uncertainty
- Two mirrored solutions with possibility for third one

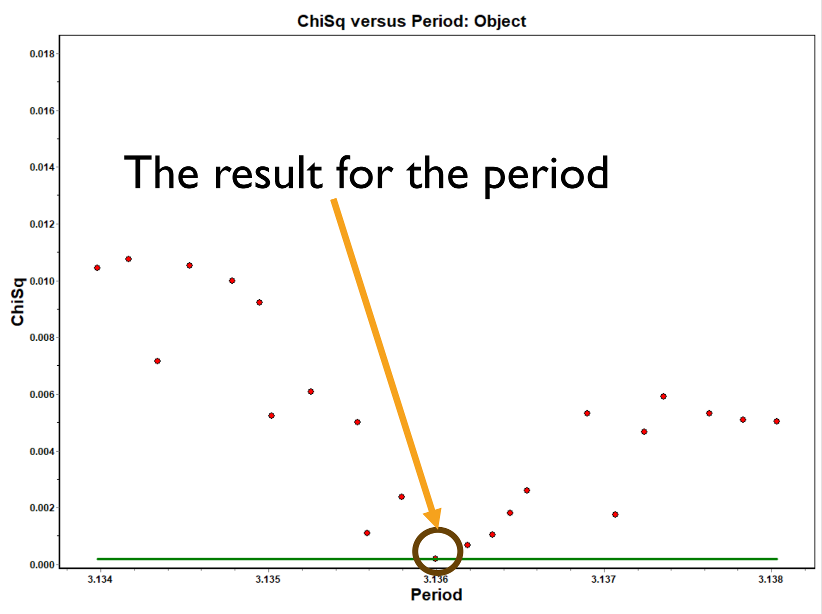




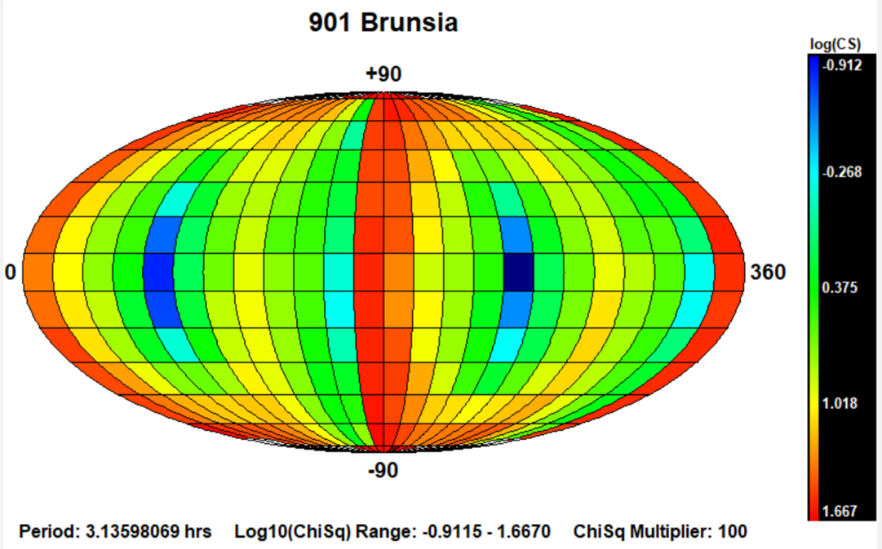
THE MODEL OF 901 BRUNSIA

In search for the possible sidereal period and model using only GAIA DR3 data

The periodogram

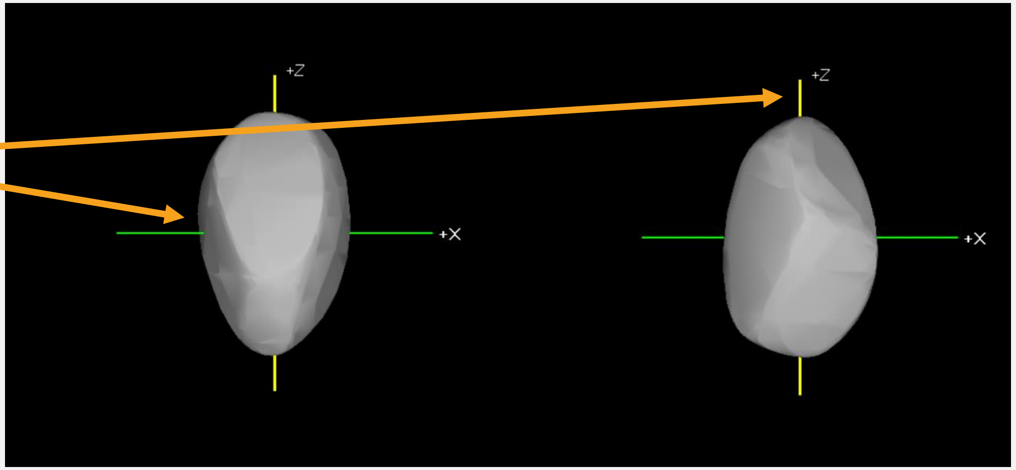


The sphere with the possible solutions for the pole coordinates



Pole 1		Pole 2	
λ (°)	β(°)	λ (°)	β(°)
240	0	60	0

The results for the shape



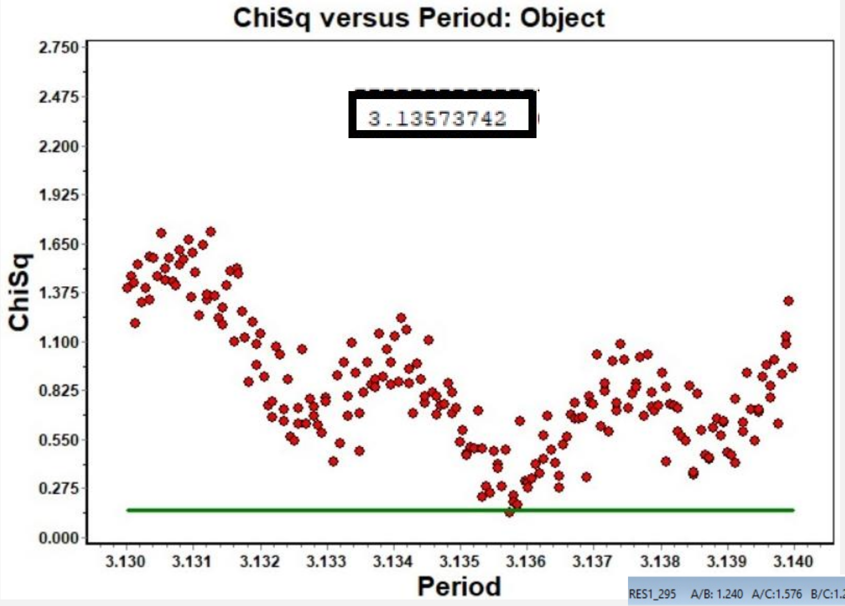
Problems ???

The axis of rotation

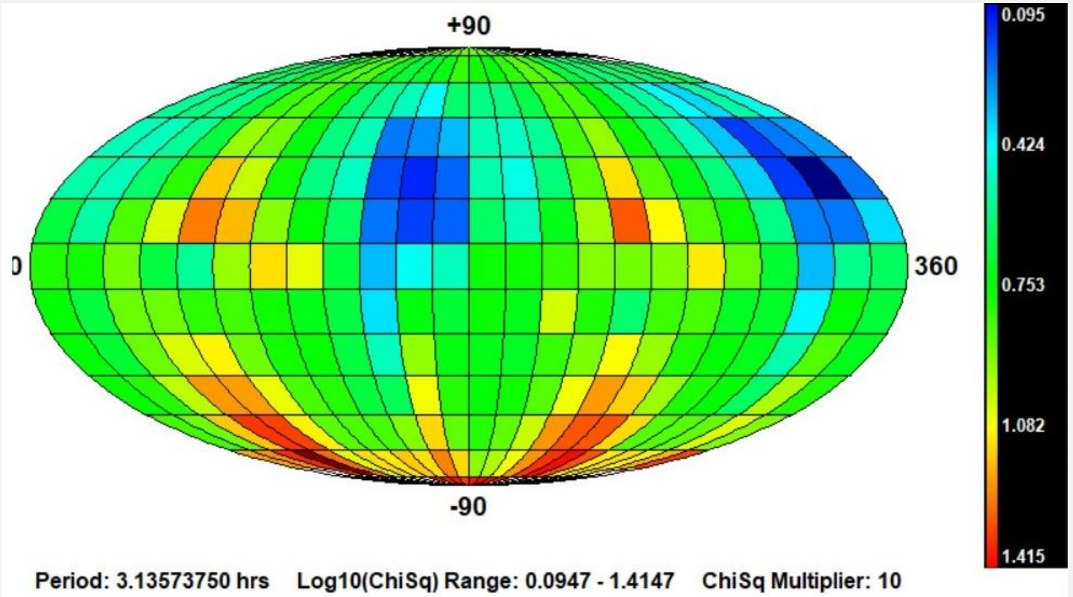
THE MODEL OF 901 BRUNSIA

In search for the possible sidereal period and model using only dense data

The periodogram

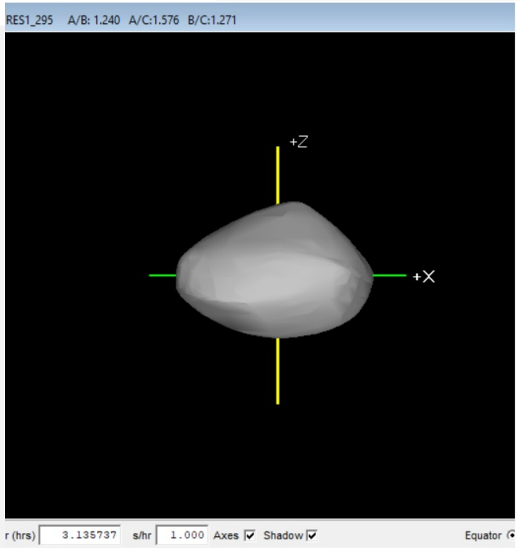


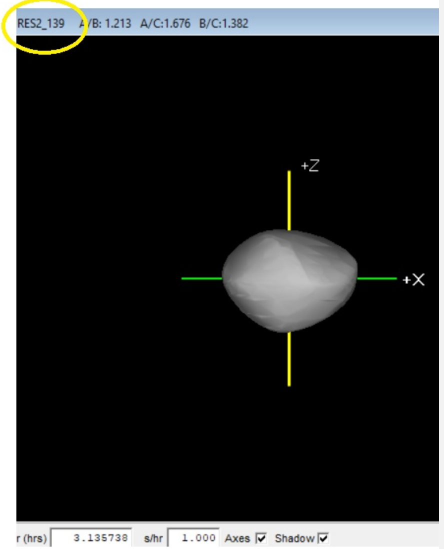
The sphere with the possible solutions for the pole coordinates



Pole 1		Pole 2	
λ (°)	β(°)	λ (°)	β(°)
330	30	150	30

The shape

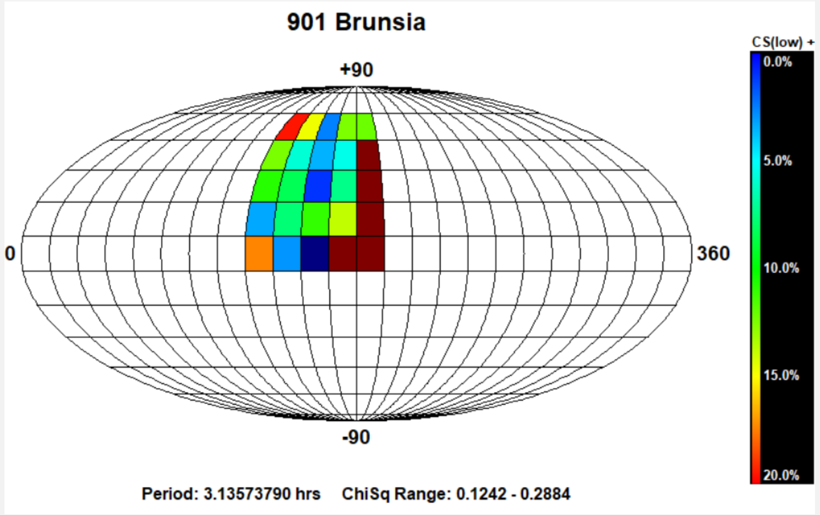


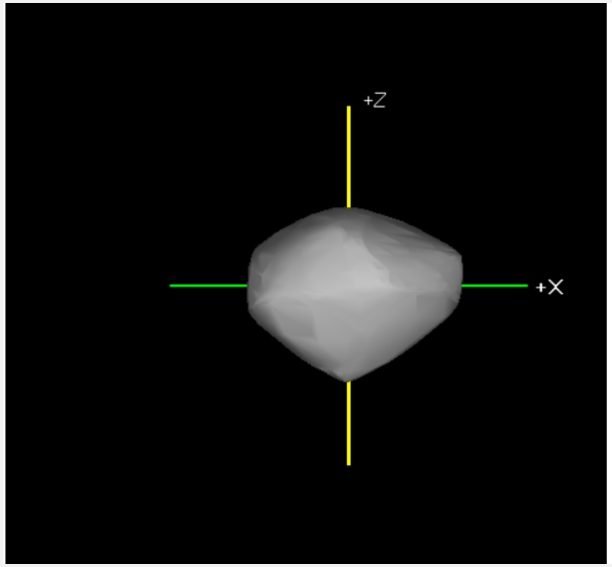


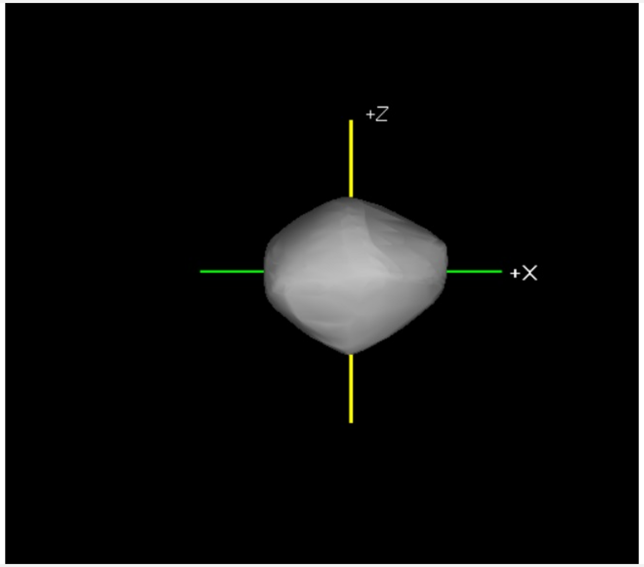
The search for the model should continue to a finer solution around this first results !!!

THE MODEL OF 901 BRUNSIA

The finnier result for the model of 901 Brunsia using only dense data







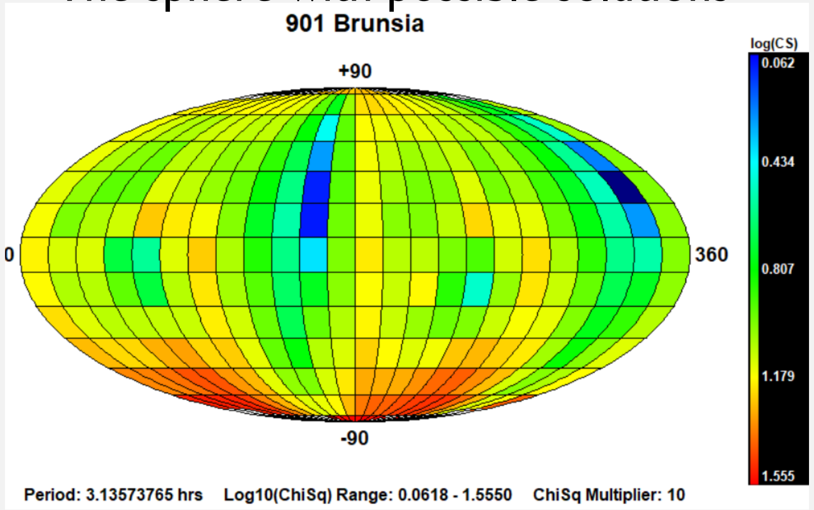
The results

Asteroid	Sidereal period (h)	Sense of rotation	Pole 1		Pole 2		a/b	b/c	a/c
			λ (°)	β(°)	λ (°)	β(°)			
901 Brunsia	3.13574	P	329,97	29,97	152,29	22,22	1,27	1,34	1,70

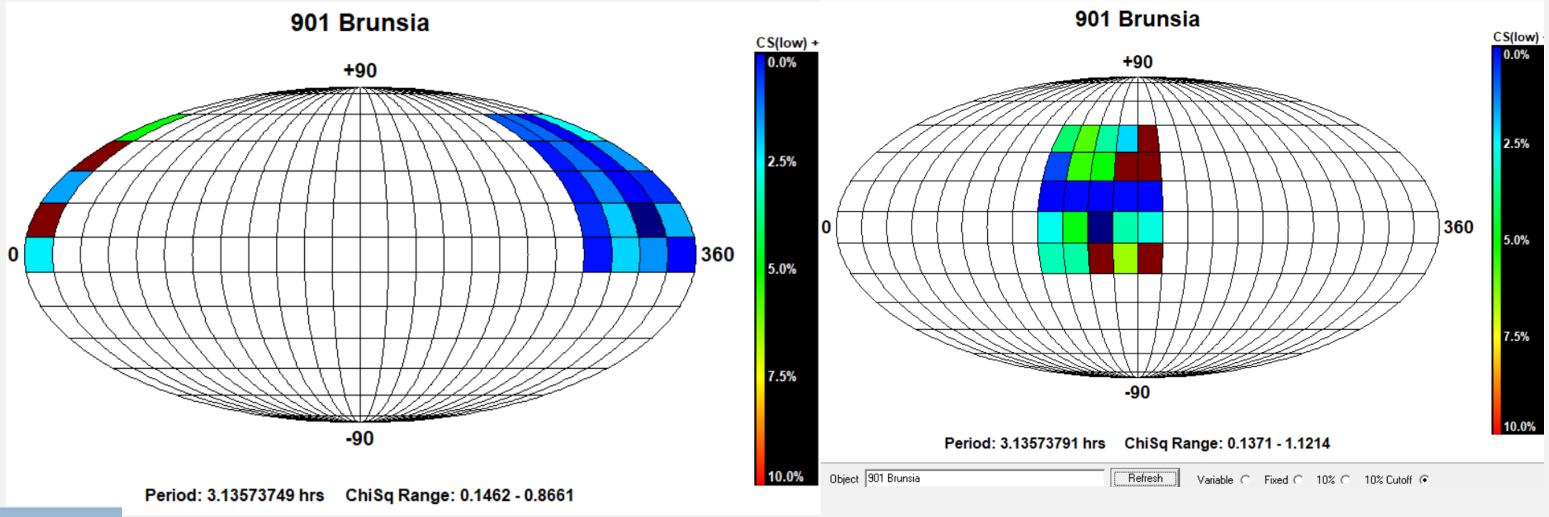
THE MODEL OF 901 BRUNSIA

The final model for the asteroid 901 Brunsia determined using the combination of dense observational data and data from GAIA DR3

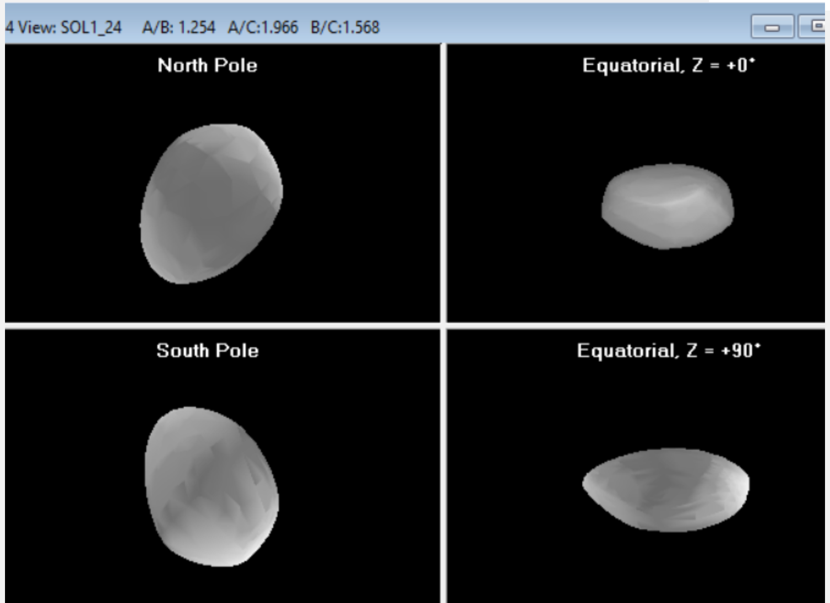
The sphere with possible solutions



The sphere with the finer solutions



The shape



The results

Asteroid	Sidereal period (h)	Sense of rotation	Pole 1		Pole 2		a/b	b/c	a/c
			λ (°)	β(°)	λ (°)	β(°)			
901 Brunsia	3.13574	P	329.8	30.4	150.8	22.8	1,25	1,57	1,97

THE MODEL OF 1011 LAODAMIA

- Mars-crosser asteroid
- Discovered in 1924
- Period of rotation 5.17 h
- Spectral class S

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DOI: 10.2298/SAJ1489079A
UDC 523.44 1011LAODAMIA
Original scientific paper

PHOTOMETRY AND SHAPE MODELING OF
MARS CROSSER ASTEROID (1011) LAODAMIA[1]

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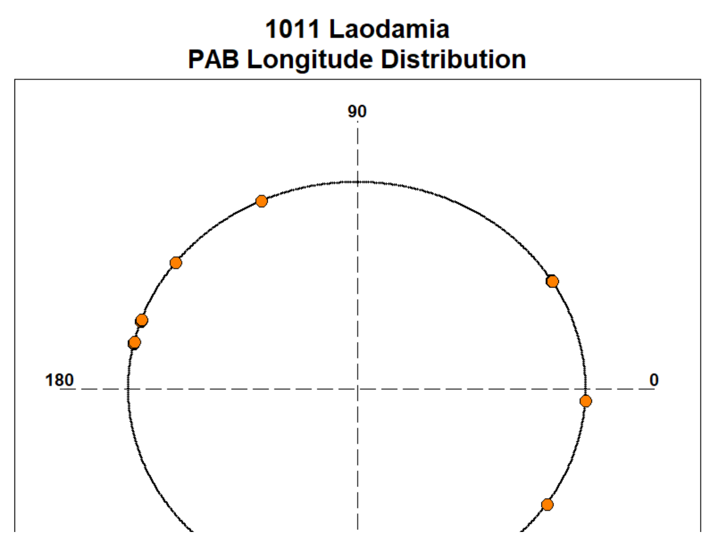
SUMMARY: An analysis of photometric observations of Mars crosser asteroid 1011 Laodamia conducted at Bulgarian National Astronomical Observatory Rozhen over a twelve year interval (2002, 2003, 2004, 2006, 2007, 2008, 2011, 2012 and 2013) is made. Based on the obtained lightcurves the spin vector, sense of rotation, and preliminary shape model of (1011) Laodamia have been determined using the lightcurve inversion method. The aim of this investigation is to increase the set of asteroids with known spin and shape parameters and to contribute in improving the model in combination with other techniques and sparse data produced by photometric asteroid surveys such as Pan-STARRS or GAIA.

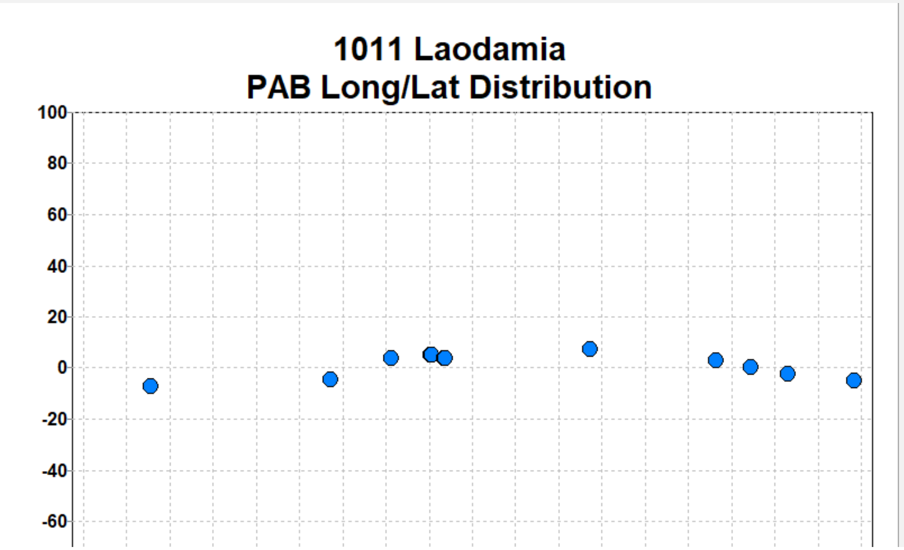
Key words. minor planets, asteroids: individual: 1011 Laodamia – techniques: photometric

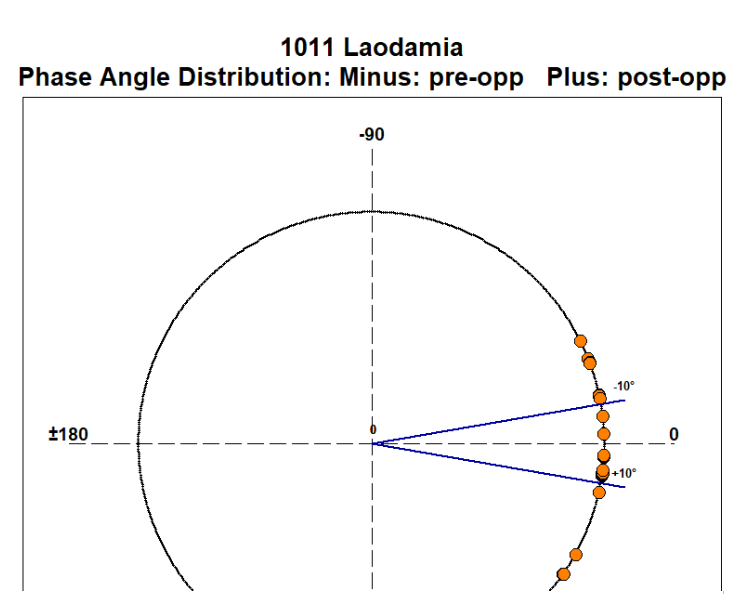
Aspect data for 1011 Laodamia

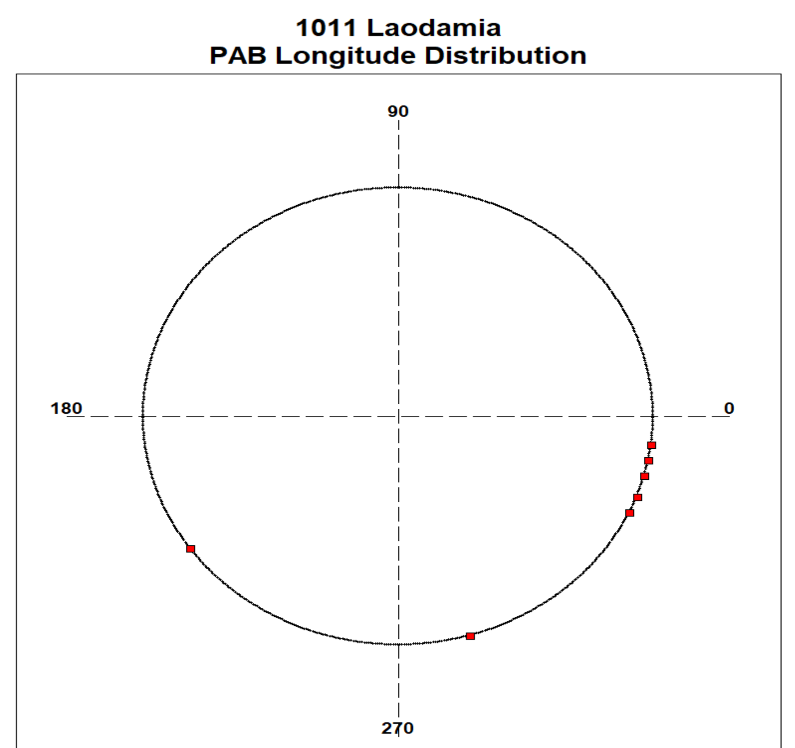
Asteroid	Date (UT)	*r* (AU)	*Δ* (AU)	Phase angle (°)	*λ* (°)	*β* (°)
1011 Laodamia	2002 Feb 10.08	1.612	0.709	21.42	177.49	5.00
	2002 Feb 12.08	1.617	0.704	20.30	177.41	5.27
	2003 June 26.98	3.157	2.187	6.68	295.89	3.15
	2004 Sept 20.98	2.692	1.692	2.39	356.43	-6.13
	2006 May 26.92	2.408	1.418	6.74	231.98	9.03
	2006 May 28.94	2.416	1.432	7.55	231.50	8.95
	2006 May 29.95	2.420	1.439	7.94	231.28	8.91
	2007 Aug 09.94	3.226	2.222	3.00	307.35	0.33
	2007 Aug 10.88	3.226	2.224	3.35	307.13	0.31
	2008 Oct 03.96	2.237	1.302	11.94	37.23	-9.06
	2008 Oct 05.98	2.229	1.284	11.09	36.87	-9.18
	2011 Sep 23.85	3.058	2.224	12.27	320.15	-2.55
	2012 Dec 14.08	1.591	0.740	26.33	127.94	-6.11
	2013 March 19.87	1.616	0.792	28.81	128.20	4.61
	2013 April 29.92	1.727	1.185	34.51	143.44	5.70
	2013 April 30.87	1.731	1.196	34.52	143.90	5.71

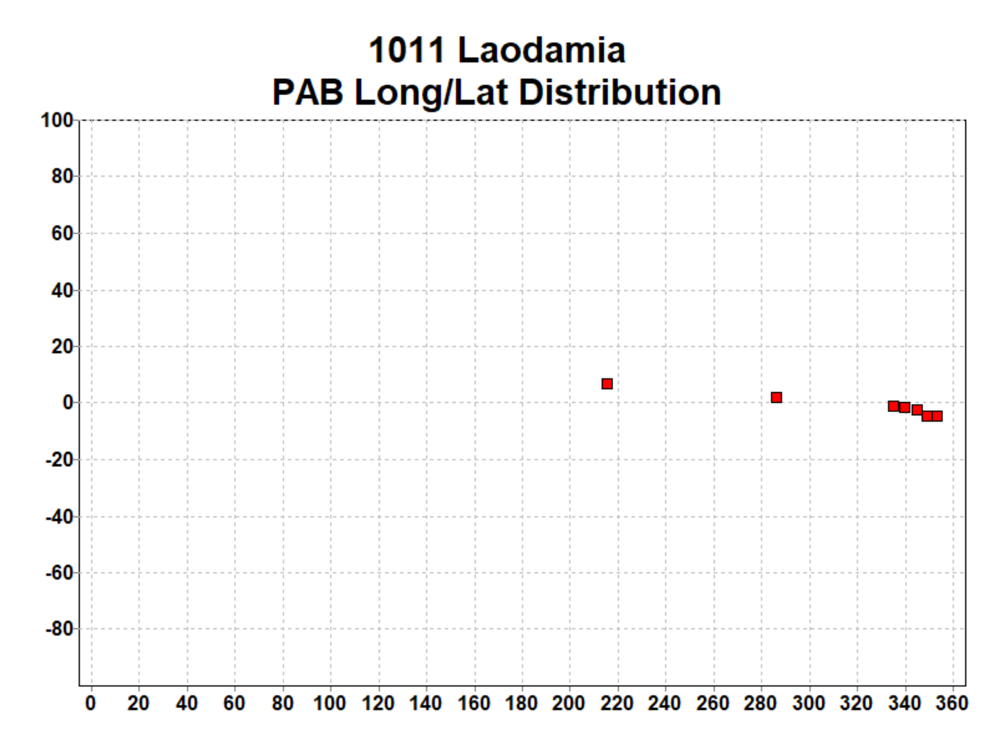
Distribution of the phase angle and PAB longitude and latitude from our dense observations (orange and blue points) and from Gaia DR3 (red points)

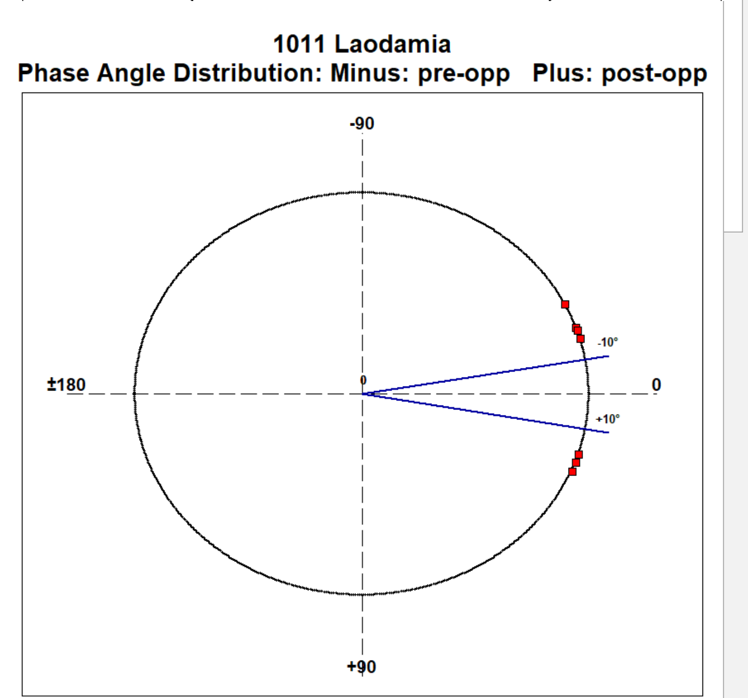












THE MODEL OF 1011 LAODAMIA

THE RESULTS FROM THE DENSE DATA

Asteroid	Sidereal period (h)	Sense of rotation	Pole 1		Pole 2	
			λ (°)	β(°)	λ (°)	β(°)
1011 Laodamia	5.17279	R	95	-88.5	272	-88.3

THE RESULTS FROM THE COMBINE DENSE AND SPARSE DATA

Asteroid	Sidereal period (h)	Sense of rotation	Pole 1		Pole 2	
			λ (°)	β(°)	λ (°)	β(°)
1011 Laodamia	5.17279	R	135	-90	300	-90

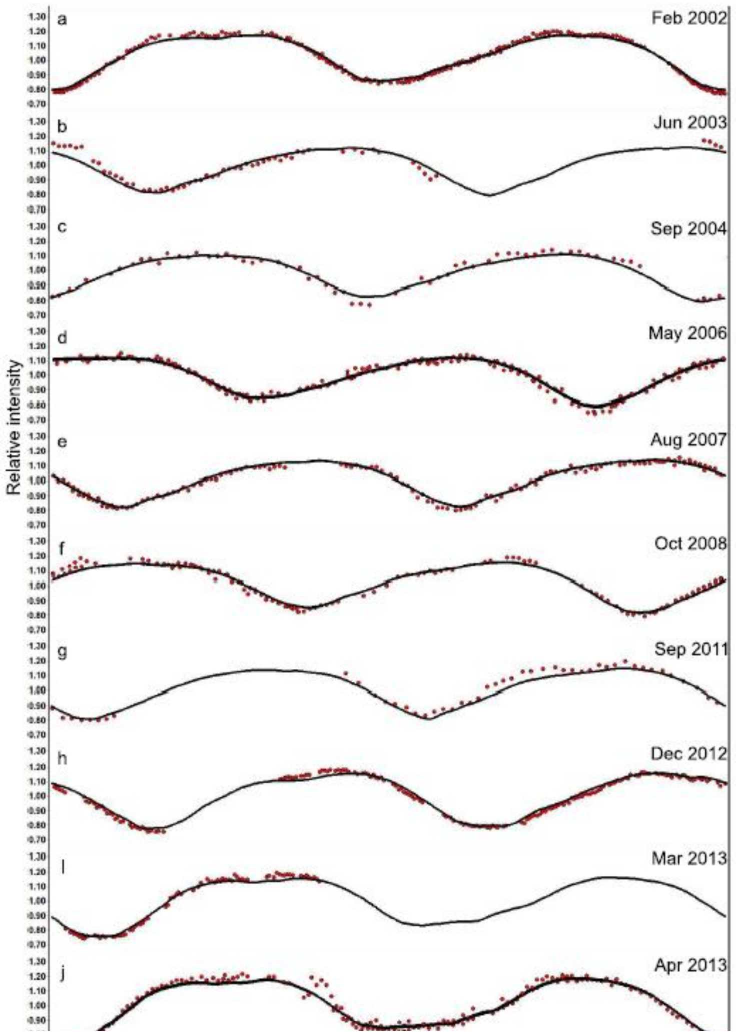
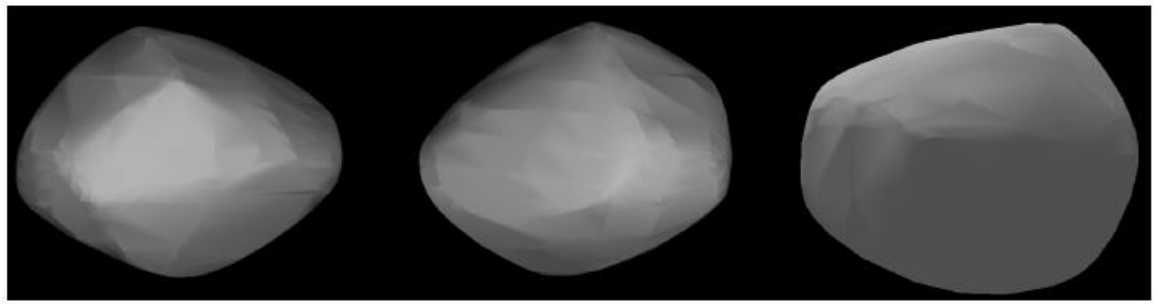
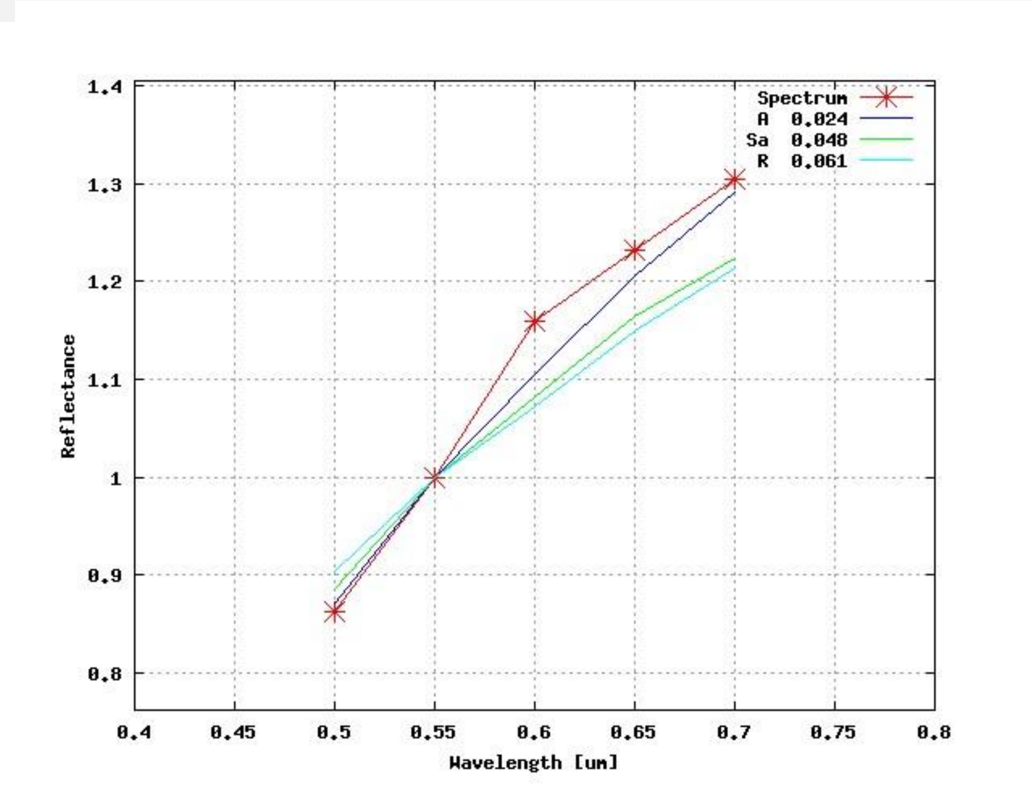


Fig. 1. *Lightcurves (points) obtained from observations in Table 1, superimposed on the lightcurves created by a model (solid line).*

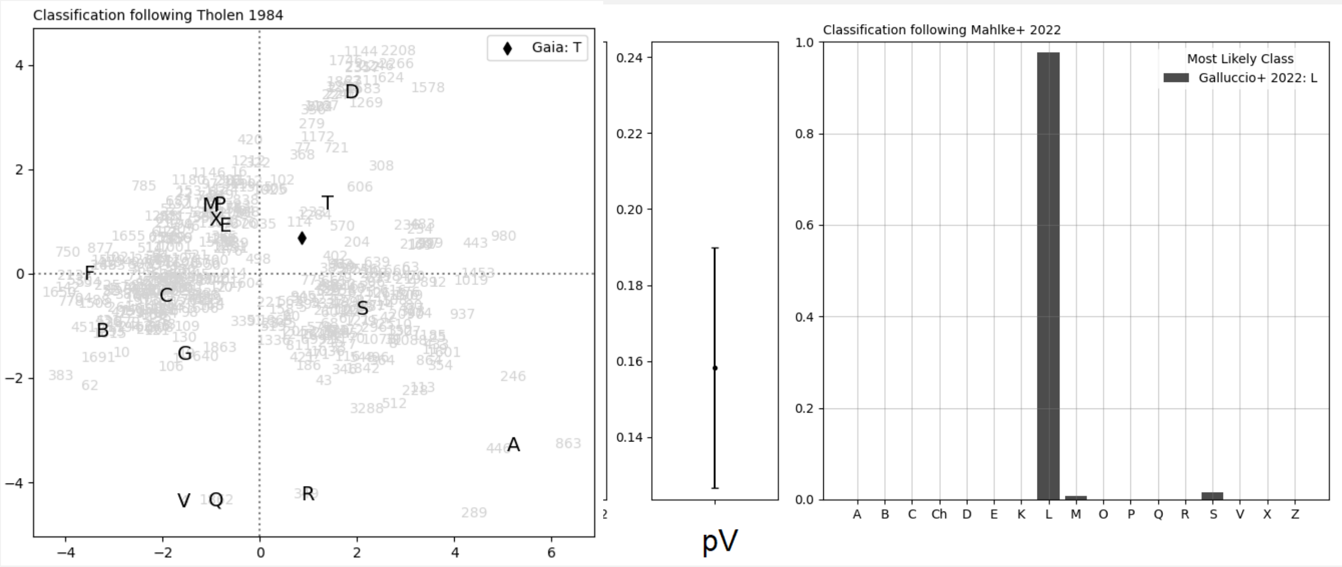


THE SPECTRA OF ASTEROIDS USING GAIA DR3 DATA

The first results for determining the spectrum of asteroid **590 Tomirys** at NAO Rozhen



Determining the spectrum using GAIA DR 3 data

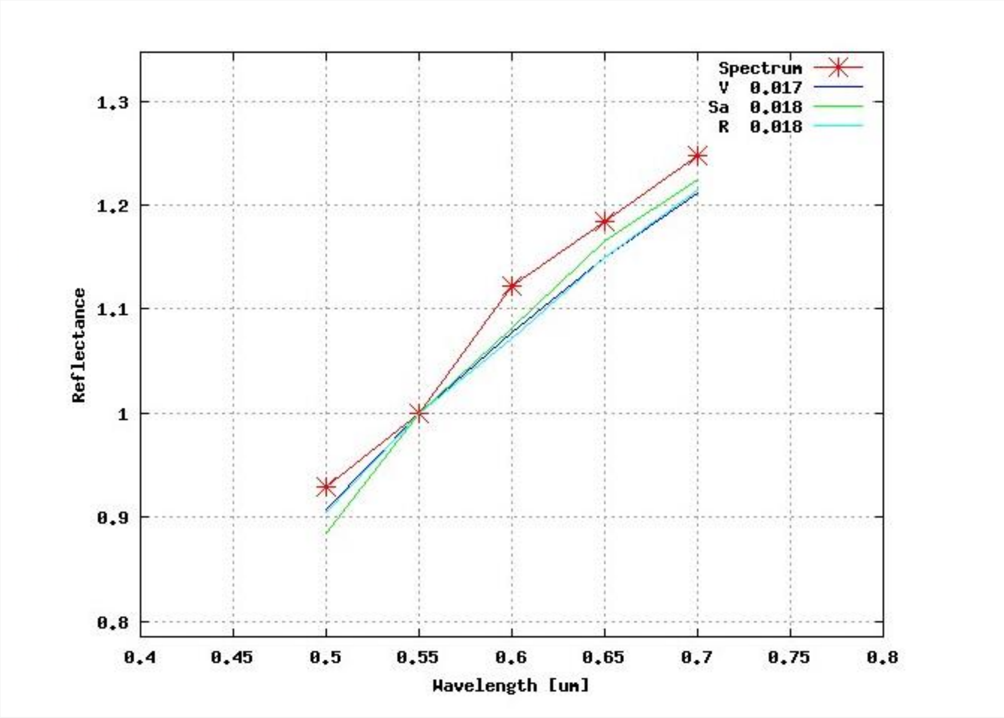


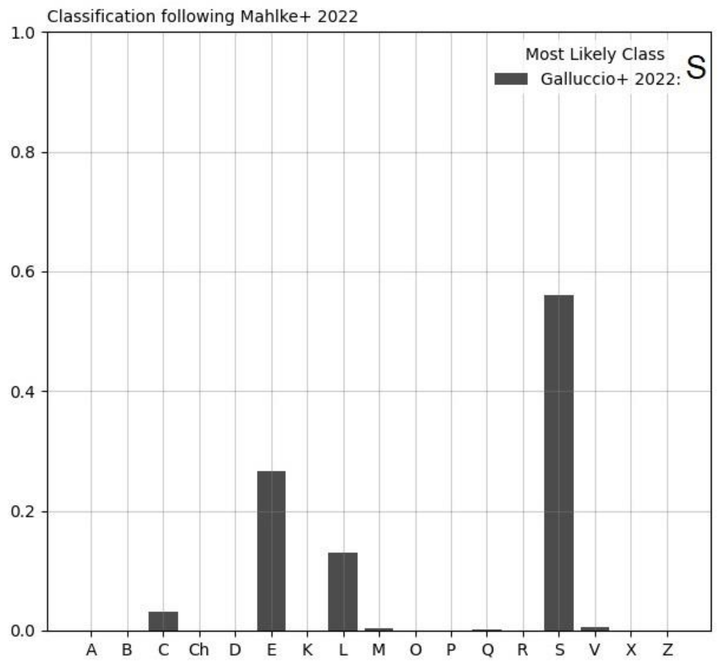
Results :

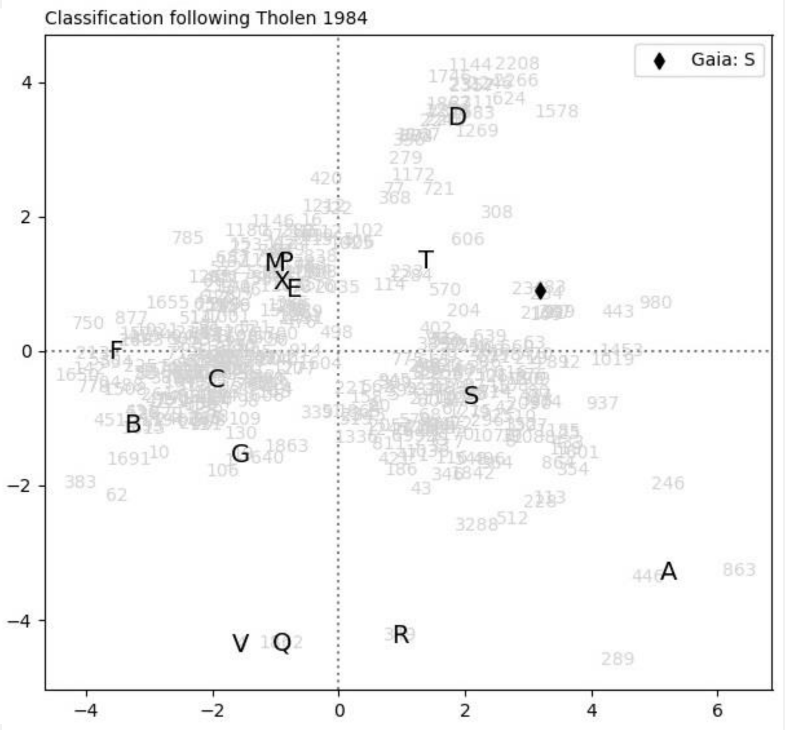
L-class according Mahkle classification – 97.7%

T-class according Tholen classificitaion

The spectra of asteroids using GAIA DR3 data







Horizons On-Line System News
https://ssd.jpl.nasa.gov/horizons/news.html

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*******************************************************
703 Noemi (A910 TD)            2023-Sep-01 04:43:11

RAD= 3.625                ROTPER= 200.
G= .150                   B-V= n.a.
ALBEDO= .368              STYP= n.a.
```

703 Noemi is a stony Florian asteroid and has published spectral class **S** assumed based on orbital group. Using GAIA DR3 and probabilistic approach proposed by Mahkle et al. (2002) we obtained that asteroid has a 56% probability of being a **S-class** 56% and 27% probability of being a E-class. Classification following Tholen also gives **S class.**

Tholen		Bus-DeMeo		This work
		Sq		
	↗	Sr	↘	
S	→	S	→	S
	↘	Sa	↗	
		Sv		

ALCDEF database

Number	Name	Desig	Family	CS	Class	DS	DF	Diam	HS	H	HB	GS	G	G1	G2	AS	AF	Albedo	PF	Period	I
703	Noemi	1910 KT	402	A	S	C		7.53	M	12.54		A	0.24			A		0.30		200.	

CONCLUSIONS

- GAIA DR3 data significantly increases the distribution of the aspect angle and phase angle – crucial for determining the model of the asteroid
- Using the GAIA DR3 can help in reducing the observations time from the ground base telescopes
- The rare points influence negatively to increasing the statistical error of the solution, but give more realistic solution for the model
- Possibility for more accurate determination of the spectral class of asteroids or in some cases an unique result for classification

work in progress:

- Creating a database and sorting observations of asteroids performed at BNAO Rozhen from 2002 till today.
- Improving the methodology for using photometric and spectroscopic data from Gaia DR3 for our observed asteroids.
- Recalculating the shape and pole solution for asteroids with already known models (obtained from our dense observations), using the data from GAIA DR3.

THANK YOU FOR YOUR ATTENTION