

Ground-based Observations of Asteroids to Support Gaia Data Exploitation

Gaia-RIA Workshop 2020
Institut de Ciències del Cosmos, Universitat de Barcelona
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STATE OF THE ART IN MINOR BODIES MODELLING

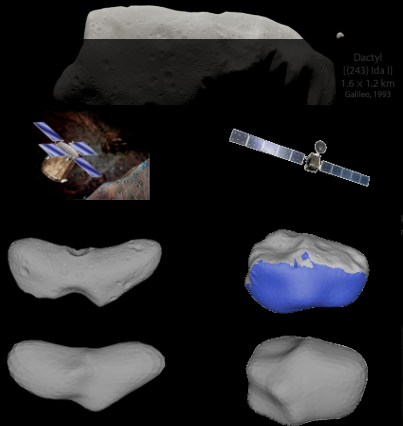
Minor bodies with ground-truth

	Visited	Targeted
Minor planets	15 (2)*	4
Comets	9	2

* Far flyby, image not resolved

Minor planets known: >850.000
Comets discovered: ~ 4.000

Source: Minor Planet Center



Dactyl
(243) Ida II
1.6 x 1.2 km
Galileo, 1993

Figure: **Top:** Artist's concept of NEAR Shoemaker (left) and Rosetta (right) spacecrafts. **Middle:** In situ imaging of 433 Eros (left) and 21 Lutetia (right). **Bottom:** Corresponding models derived with the SAGE inversion technique from ground-based lightcurves only (Bartczak, Santana-Ros et al., ACM 2014).

21 Lutetia - 132 x 101 x 76 km
Rosetta, 2010

19P/Borrelly - 16 x 8 x 8 km
Vega 2, 1986

19P/Borrelly
8 x 4 km
Deep Space 1, 2001

9P/Tempel 1
7.6 x 4.9 km
Deep Impact, 2005

81P/Wild 2
5.5 x 4.0 x 3.3 km
Stardust, 2004

103P/Hartley 2
2.2 x 0.5 km
Deep Impact/EPOXI, 2010

67P/Churyumov-Gerasimenko
4.1 x 3.2 x 2.5 km
Rosetta, 2014

Knowledge from remote observations

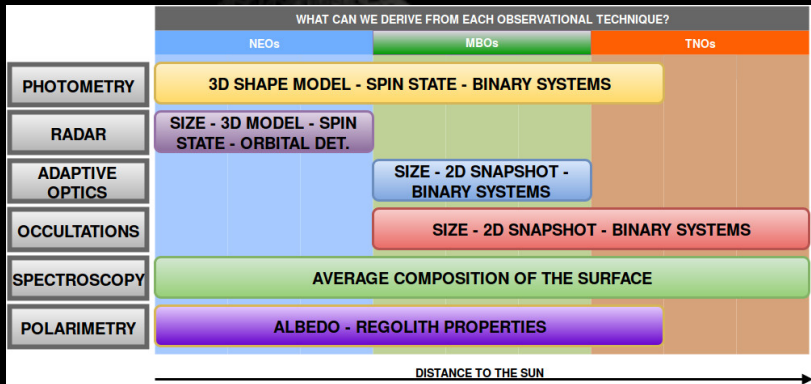


Figure: Physical properties derived from remote observations

Asteroid modeling: Lightcurves are the main source

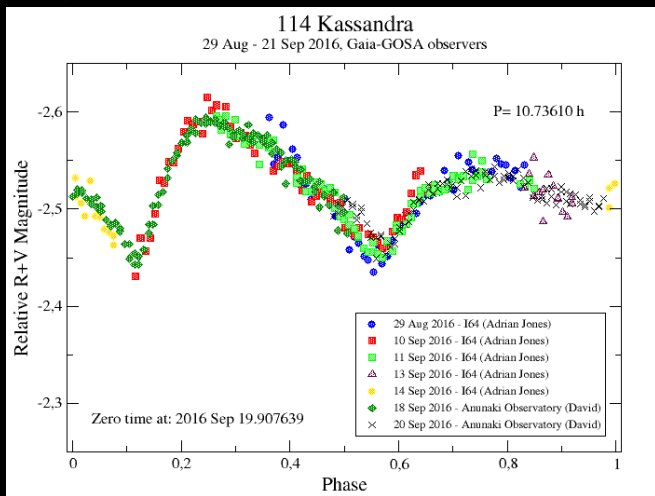


Figure: A composite lightcurve of main belt asteroid 114 Kassandra.

Asteroid modeling: Inversion technique

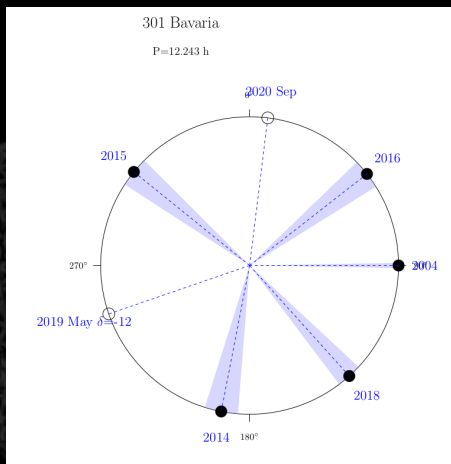


Figure: Earth-centered ecliptic longitudes of an asteroid at different apparitions.

>2400 shape models available



MINOR BODIES MEET
BIG DATA

What we do have so far? Gaia DR2

Asteroid content in Gaia DR2

14 099 objects

1 977 702 observations

22 months

CLICK ME!

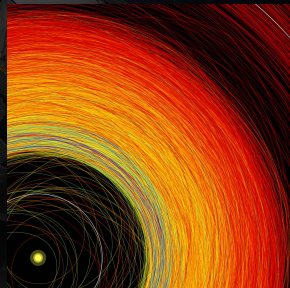


Figure: Asteroid orbits derived from DR2. Orbits are coloured following the albedo of asteroids.

Asteroid sparse data from Gaia DR2

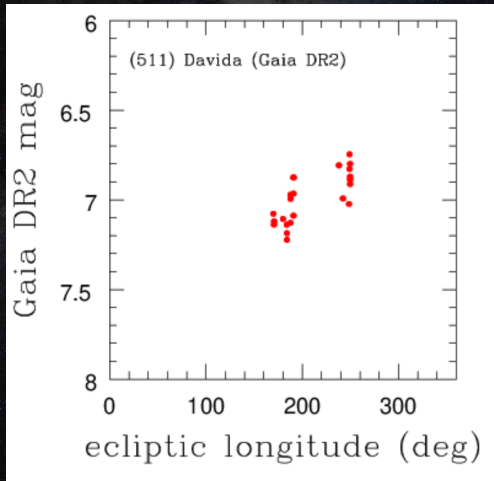
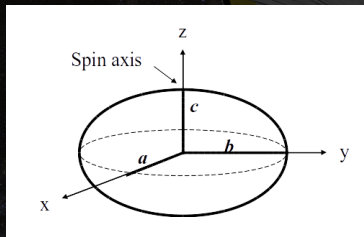


Figure: Gaia DR2 photometry of asteroid 511 Davida.

Asteroid modeling with Gaia data: Genetic algorithm

We assume that the objects can be represented by **triaxial ellipsoids** (In order to avoid highly CPU intensive calculations).

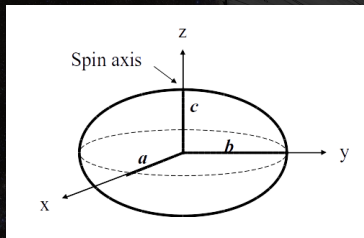


The Gaia genetic algorithm (Cellino et al. 2014) search for the best fit of:

- Pole coordinates (λ, β)
- Sidereal Rotation Period (P)
- Axial Ratios ($b/a, c/a$)
- Rotational phase at epoch of first observations (ϕ_0)

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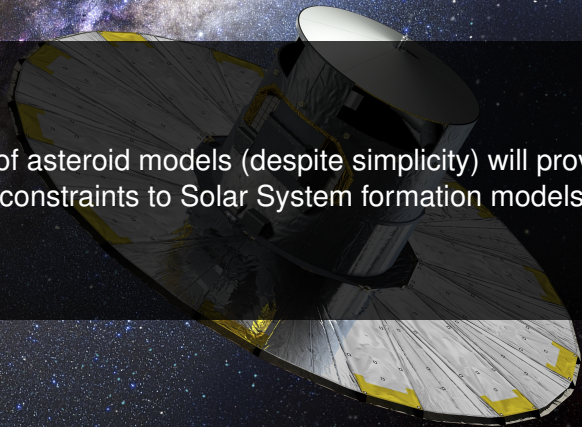
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DR2 DR3

Asteroid modeling with Gaia data

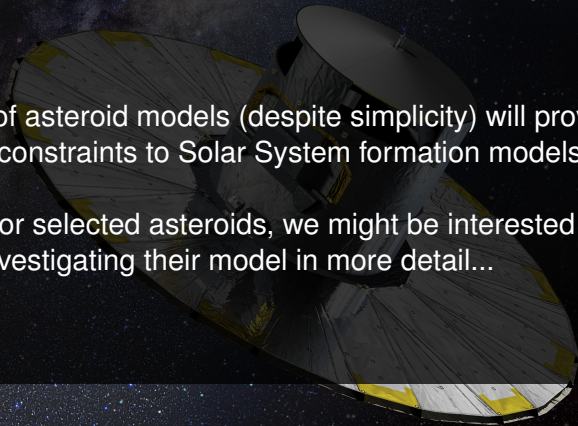
Thousands of asteroid models (despite simplicity) will provide powerful constraints to Solar System formation models.



Asteroid modeling with Gaia data

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However, for selected asteroids, we might be interested in investigating their model in more detail...



Asteroid modeling with Gaia data

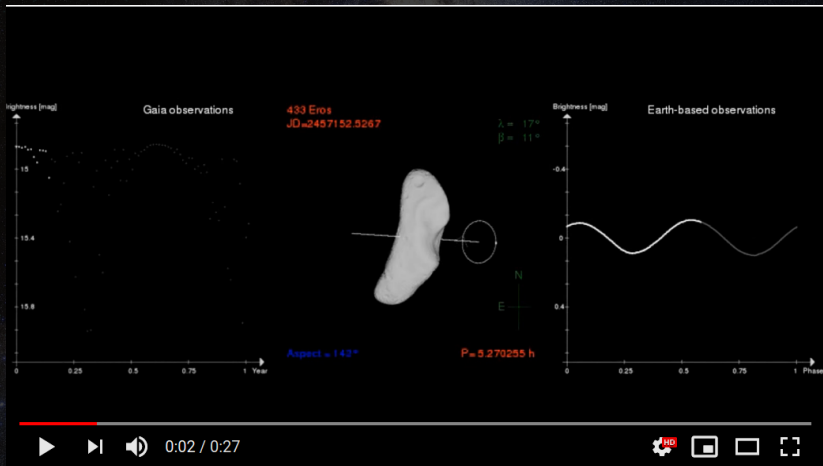


Thousands of asteroid models (despite simplicity) will provide powerful constraints to Solar System formation models.

However, for selected asteroids, we might be interested in investigating their model in more detail...

- Perturbers (large asteroids with measurable gravitational perturbation)
- Binary candidates (currently working on an automatic detection algorithm)
- Particularly interesting objects, such as mission targets, etc

Gaia vs ground-based



CLICK ME!

GROUND-BASED PHOTOMETRIC OBSERVATIONS IN SUPPORT OF GAIA



Gaia-GOSA: A network of amateur astronomers

www.gaiagosa.eu

The screenshot shows the Gaia-GOSA website interface. On the left is a dark navigation menu with the GOSA logo and links for Home, Gaia status, Guide, Observation planner, Forum, FAQ, and About. Below the menu is a 'Top 10 observers' section with a sort dropdown and a list of users with their observation counts. The main content area has a top bar with 'Home', 'Active Users: 154', 'Observations: 695', 'Forum posts: 319', and the current date/time '2020-02-14 23:14:17 UTC'. The 'News' section contains three articles: 'Paper on Gaia mass asteroids accepted' (with an image of an asteroid), 'Targets for January' (listing targets Irene and Daphne), and 'New publication with contribution from GaiaGOSA' (with an image of a star field). Below the news is a 'Follow-up targets' section with a table of asteroids.

Asteroid id	Completeness	Visible until	Magnitude range	Preliminary period	Observation strategy	Priority	External resources
(27) Euterpe	93% [alt]	04-04-2020	9.4 - 11.5	10.408 h	One frame every 10-20 minutes	Critical	-
(15) Eunomia	33% [alt]	11-12-2019	9.5 - 9.9	5.699 h	Long period and low amplitude	Critical	-
(14) Irene	76% [alt]	03-01-2020	11.2 - 11.7	15.028 h		Critical	-
(41) Daphne	89% [alt]	01-01-2020	12.3 - 13.2	5.388 h	Period resonance. Do not observe more than once.	Critical	-
(63) Ausonia	73% [alt]	15-03-2020	11 - 12.8	9.298 h		Important	-
(4869) Aegle	61% [alt]	01-01-2020	11.1 - 13	9.933 h		Important	-

Figure: A screenshot of the Gaia-GOSA main page (Santana-Ros et al. 2014)

Gaia-GOSA: Observers ranking

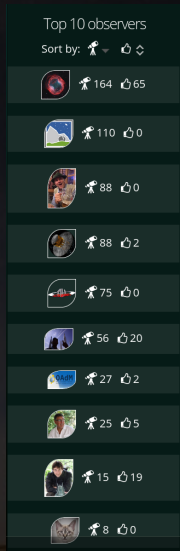


Figure: Current observers ranking.

Gaia-GOSA: Observers ranking



Figure: Current observers ranking.

Gaia-GOSA: Observers ranking

2016-09-17 12:47
Registration date

110
Observations

82
Processed observations

david

No default equipment

Default observation site
AnunakiObservatory2018

Follow

Connect

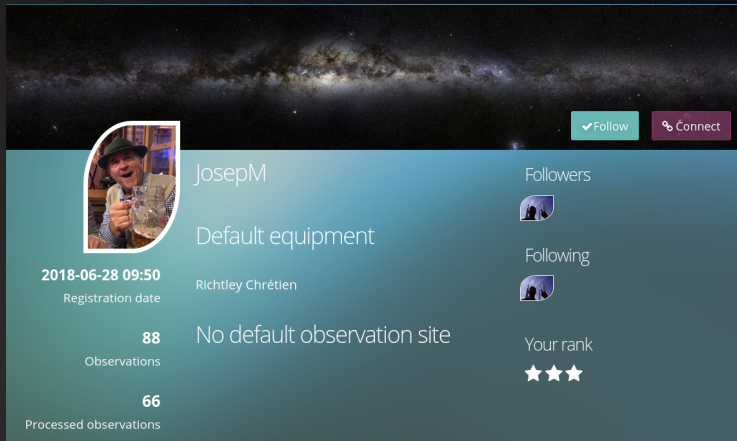
Followers

Following

Your rank
☆☆☆

Figure: Anunaki Observatory Z51 (Manzanares el Real, Madrid).

Gaia-GOSA: Observers ranking



The screenshot shows a user profile for 'JosepM' on the Gaia-GOSA platform. The background is a dark space image of the Milky Way galaxy. The profile card has a teal-to-blue gradient background. At the top right, there are two buttons: a teal 'Follow' button with a checkmark icon and a purple 'Connect' button with a network icon. The profile includes a circular profile picture of a man in a hat holding a glass, a registration date of '2018-06-28 09:50', and statistics for '88 Observations' and '66 Processed observations'. The user's name 'JosepM' is displayed in large white text. Below the name, it says 'Default equipment' and 'No default observation site'. On the right side, there are sections for 'Followers' and 'Following', each with a small circular profile picture icon. At the bottom right, the 'Your rank' is shown as three white stars.

Follow Connect

JosepM

Followers

Following

Your rank
☆☆☆

2018-06-28 09:50
Registration date

88
Observations

66
Processed observations


Default equipment

No default observation site

Richtley Chrétien

Figure: Observatori Astronòmic de les Planes de Son C29 (Lleida).

Gaia-GOSA: Observers ranking



2017-11-20 13:32
Registration date

75
Observations

48
Processed observations




Astrohenares

Default equipment
El Cerro


Default observation site
El Cerro

Follow Connect

Followers

Following



Your rank
★★★

Figure: Astrohenares (Coslada, Madrid).

Gaia-GOSA: Observers ranking

OAdM
Observatori Astronòmic del Montsec C65

2015-10-15 22:23
Registration date

27
Observations

27
Processed observations

OAdM

Default equipment
Joan Oro

Default observation site
OAdM

Followers


Following

Your rank
★★★

Follow Connect

Figure: Observatori Astronòmic del Montsec C65 (Lleida).

Gaia-GOSA: Observers ranking



mario

[Follow](#) [Connect](#)




2016-10-11 14:05
Registration date


25
Observations

17
Processed observations

No default equipment

Default observation site
Observatorio de Sencelles - MPC K14

Followers
  

Following


Your rank
★☆☆

Figure: Observatori de Sencelles K14 (Mallorca).

Gaia-GOSA: Observers ranking

2018-10-14 19:32
Registration date

8
Observations

5
Processed observations

hugogr

Default equipment
RCOS-STL

Default observation site
Observatorio de Forcarei

Follow

Connect

Followers

Following
Nobody

Your rank
☆☆☆

Figure: Observatorio de Forcarei Z62 (Pontevedra).

Telescopi Joan Oró

We have an active project in TJO (p249) to gather photometry of selected asteroids.



Figure: Telescopi Joan Oró (OAdM).

THANK YOU

GAME OVER

NEW GAME

EXIT