Observing Targets: Asteroids

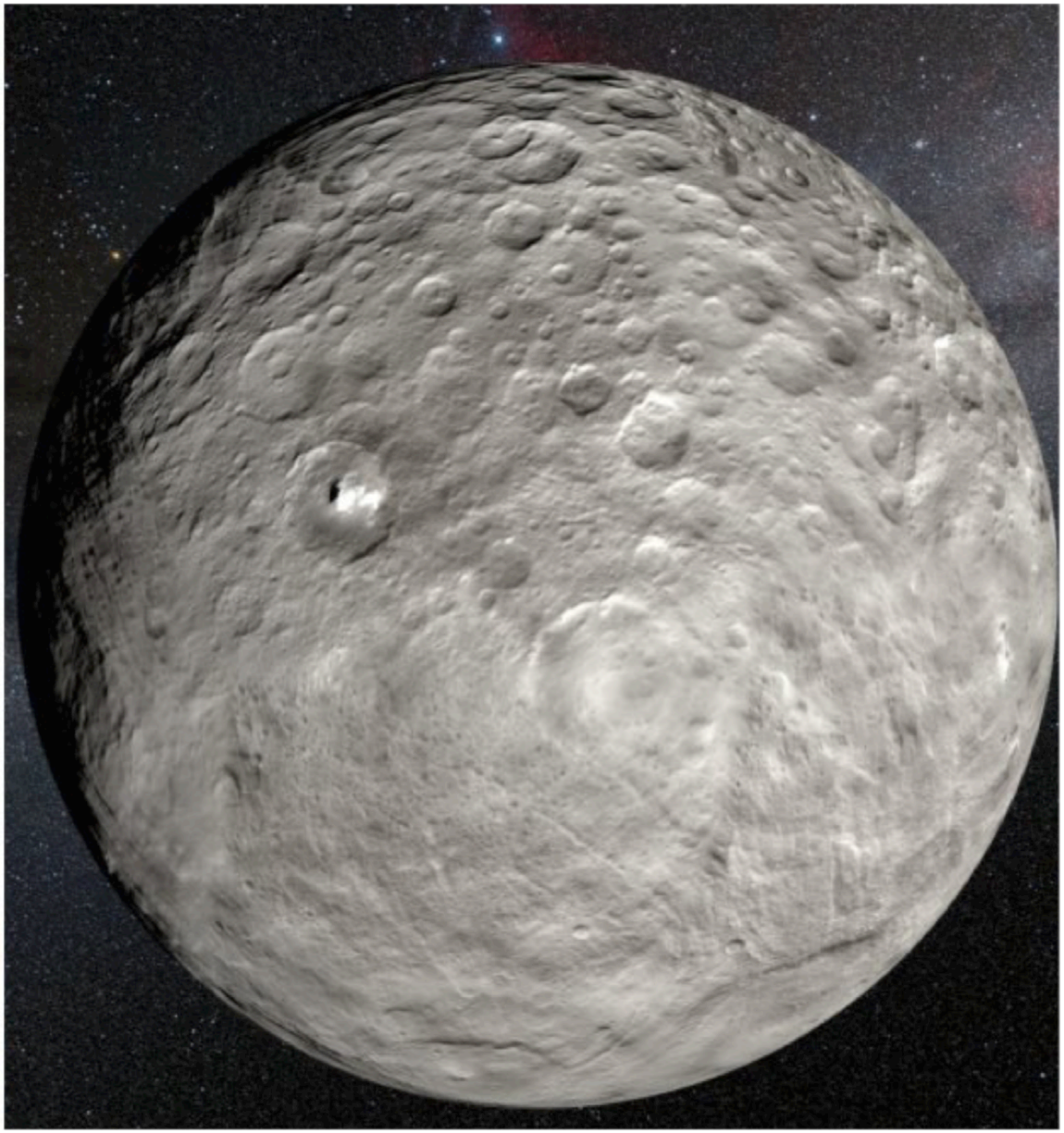
Discovery of Asteroids

Johann Titius (1729-1796)

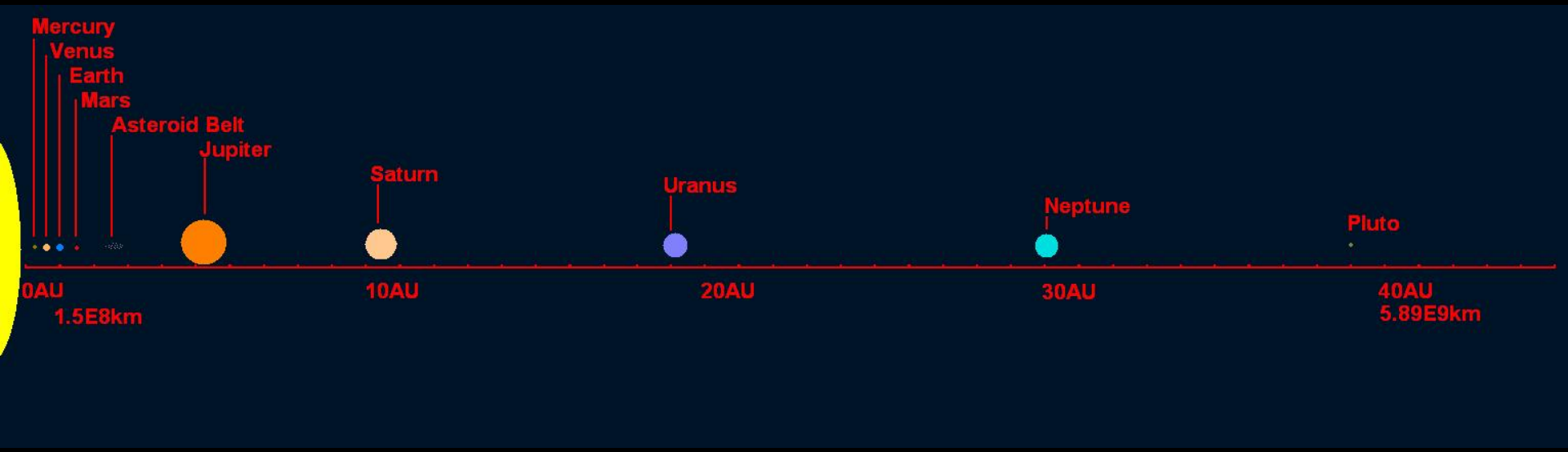
Johann Bode (1747-1846)

Giuseppe Piazzi discovered Ceres in 1801

Giussepe Piazzi (1746-1826)



Scale of Solar System



The sem-major axis of the orbit of the Earth about the Sun is one Astronomical Unit, (A.U.), 1 A.U. = 149,597,870.700 km.

Scale of Solar System

Planet	Semi-major axis, a
Mercury	0.387 Astronomical Units
Venus	0.723 Astronomical Units
Earth	1.000 Astronomical Units
Mars	1.524 Astronomical Units
Jupiter	5.204 Astronomical Units
Saturn	9.583 Astronomical Units

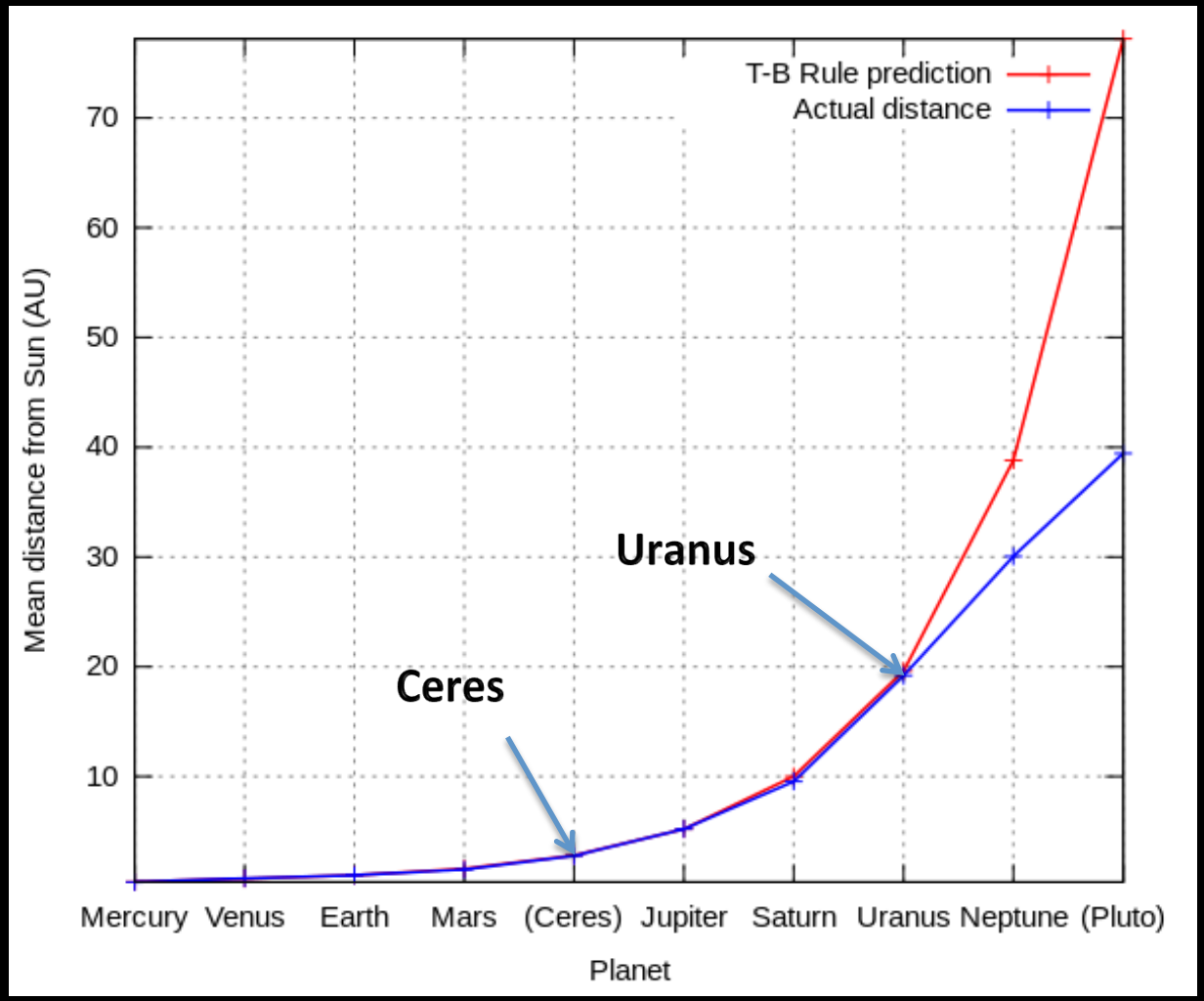
Titius-Bode Law

It was noticed that the planet's orbital sizes (a, semi-major axis) could be fit by a simple numerical series,

$$a = 0.1 \times (4+3n) \text{ A.U.}$$

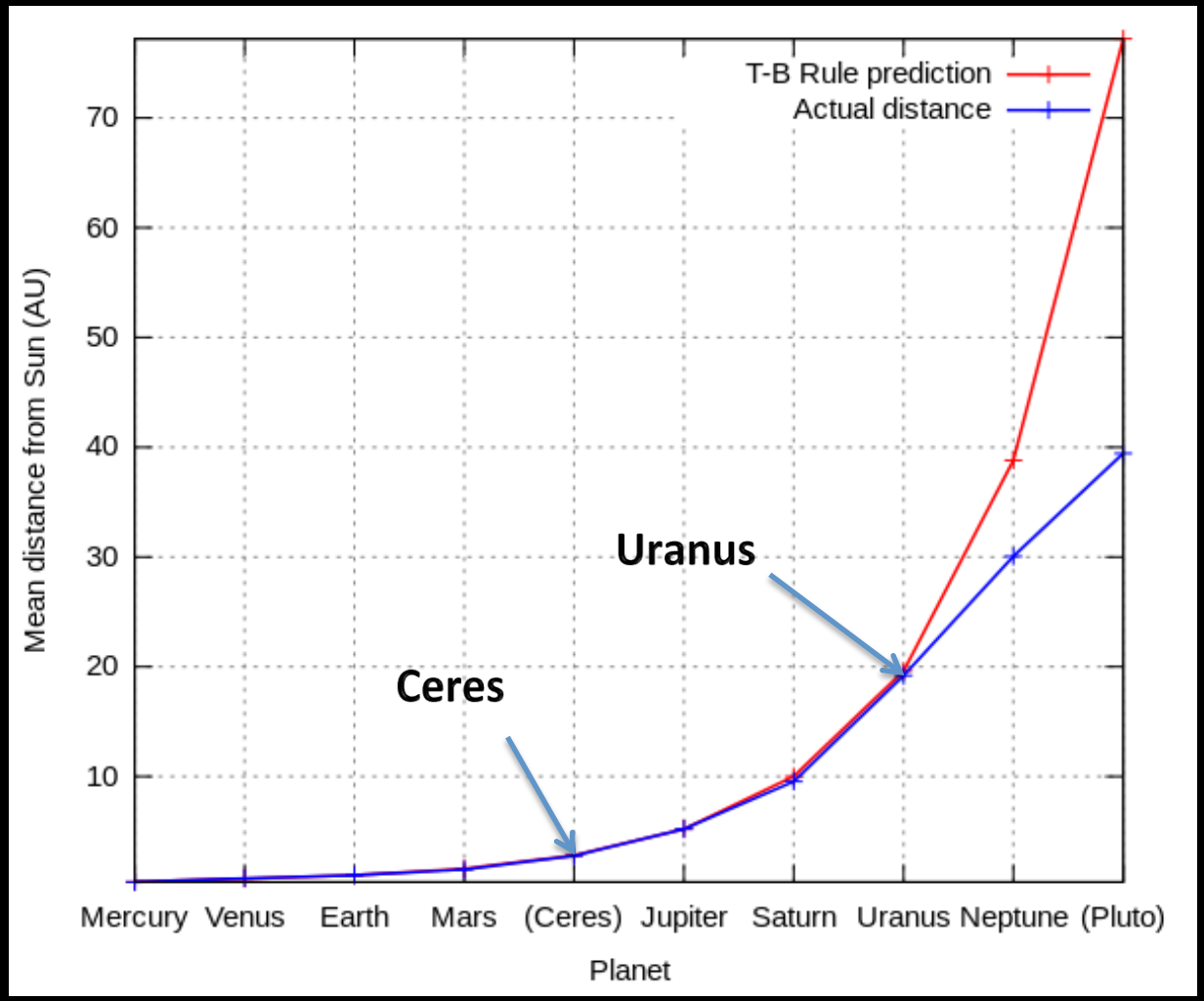
Here $n = 0, 1, 2, 4, 8, 16, 32, 64, \ldots$

Titius-Bode Law



The result preceded the discovery of Uranus (1781) and the asteroids (Ceres, 1801), and the outer planets, Neptune and Pluto and the Kuiper belt objects.

Titius-Bode Law



INTERESTING, BUT IT IS NOT CLEAR IF THERE IS PHYSICAL CONTENT IN THE TITIUS-BODE LAW

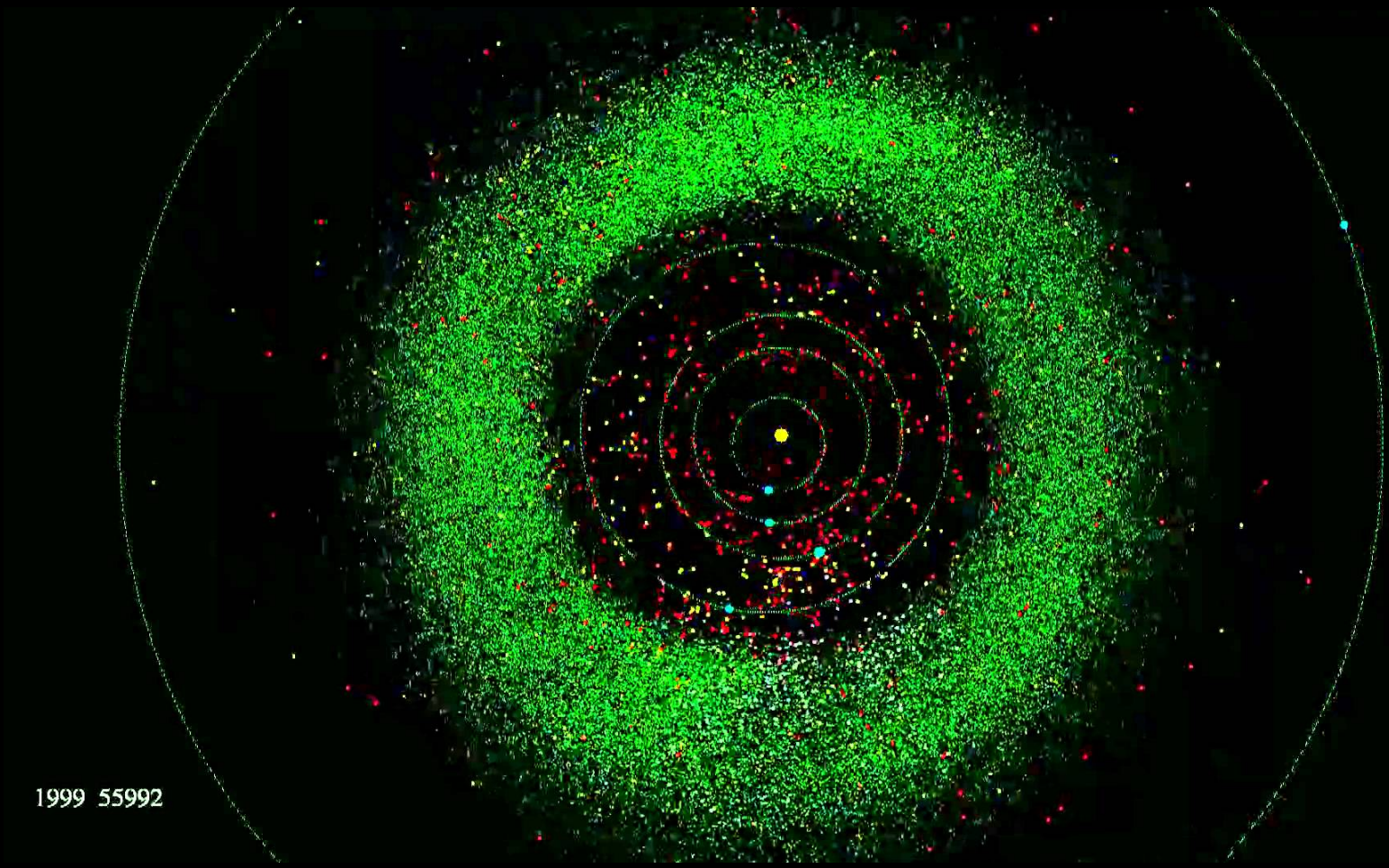
Many asteroids are left-overs from the planet formation process, large chunks of rock ranging in size from less than a meter to nearly 1,000 kilometers. Asteroids offer clues to the environment in which Terrestrial planets formed and help to elucidate how and where Earth-like planets formed in the protoplanetary nebula.

Itokawa from Hyabusa

Classes of Asteroids

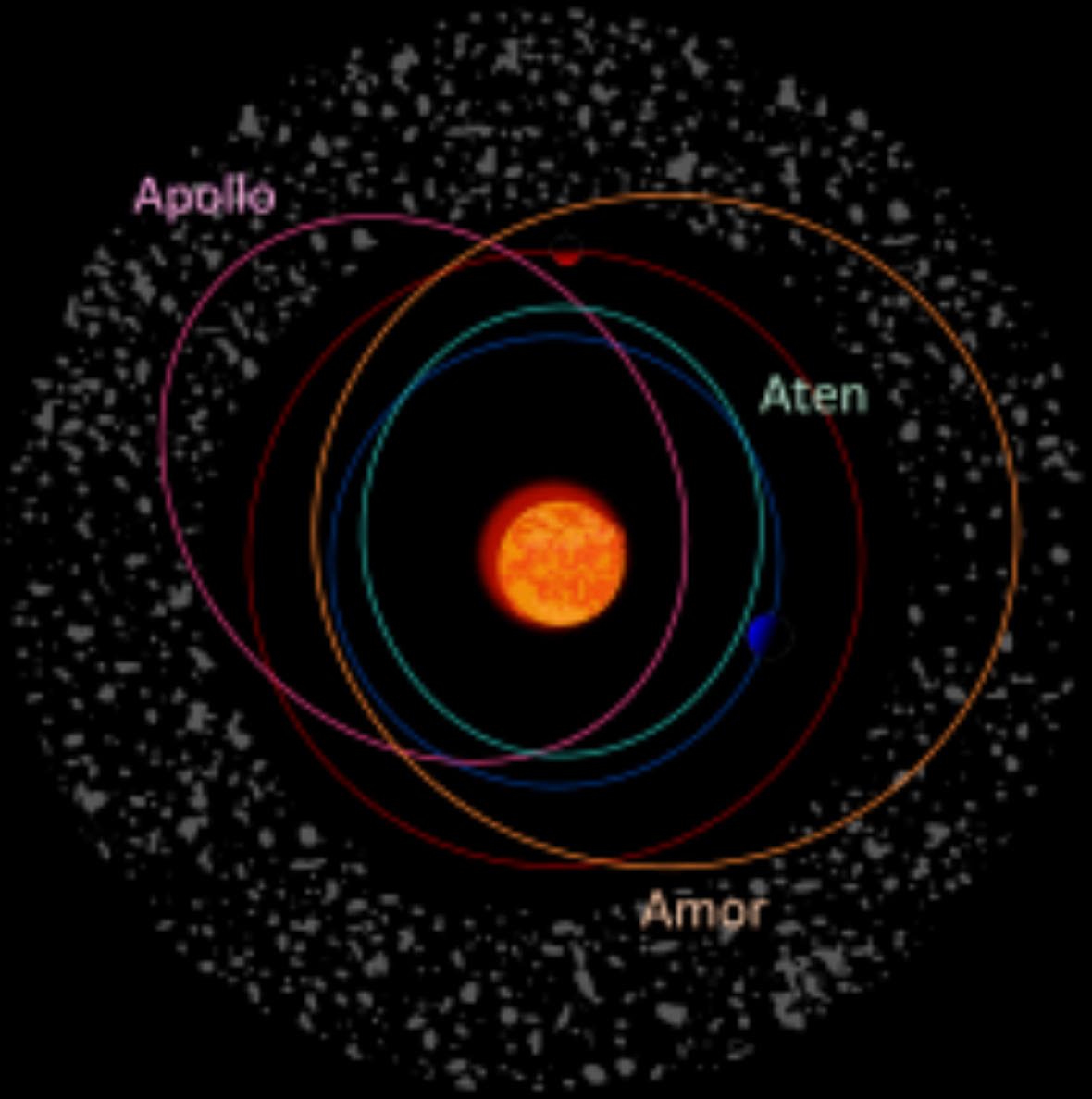
- The main belt asteroids are found between the orbits of Mars and Jupiter. The bulk of the asteroids fall between 2.06 A.U. and 3.28 A.U., the radii of the 4:1 and 2:1 Kirkwood gaps. Using Kepler's 3rd Law of Planetary Motion, $P(yr) = a(A.U.)^{1.5}$, the orbital periods of the main belt asteroids range from 3 yr to 6 yr.

Main Belt Asteroids



Other Asteroids

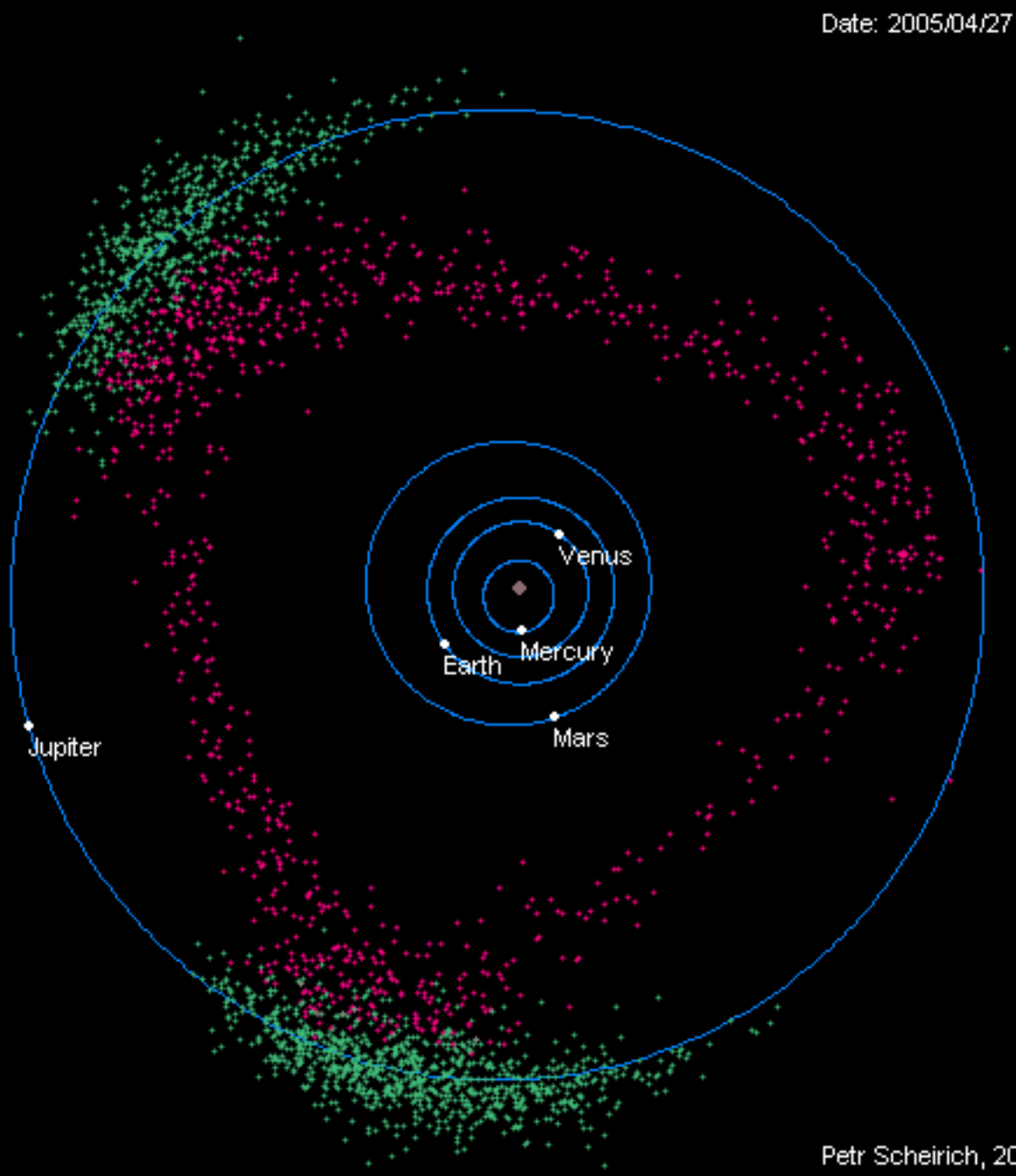
- Earth crossing asteroids, Aten and Apollo-Amor asteroids



Near Earth Asteroids

Other Asteroids

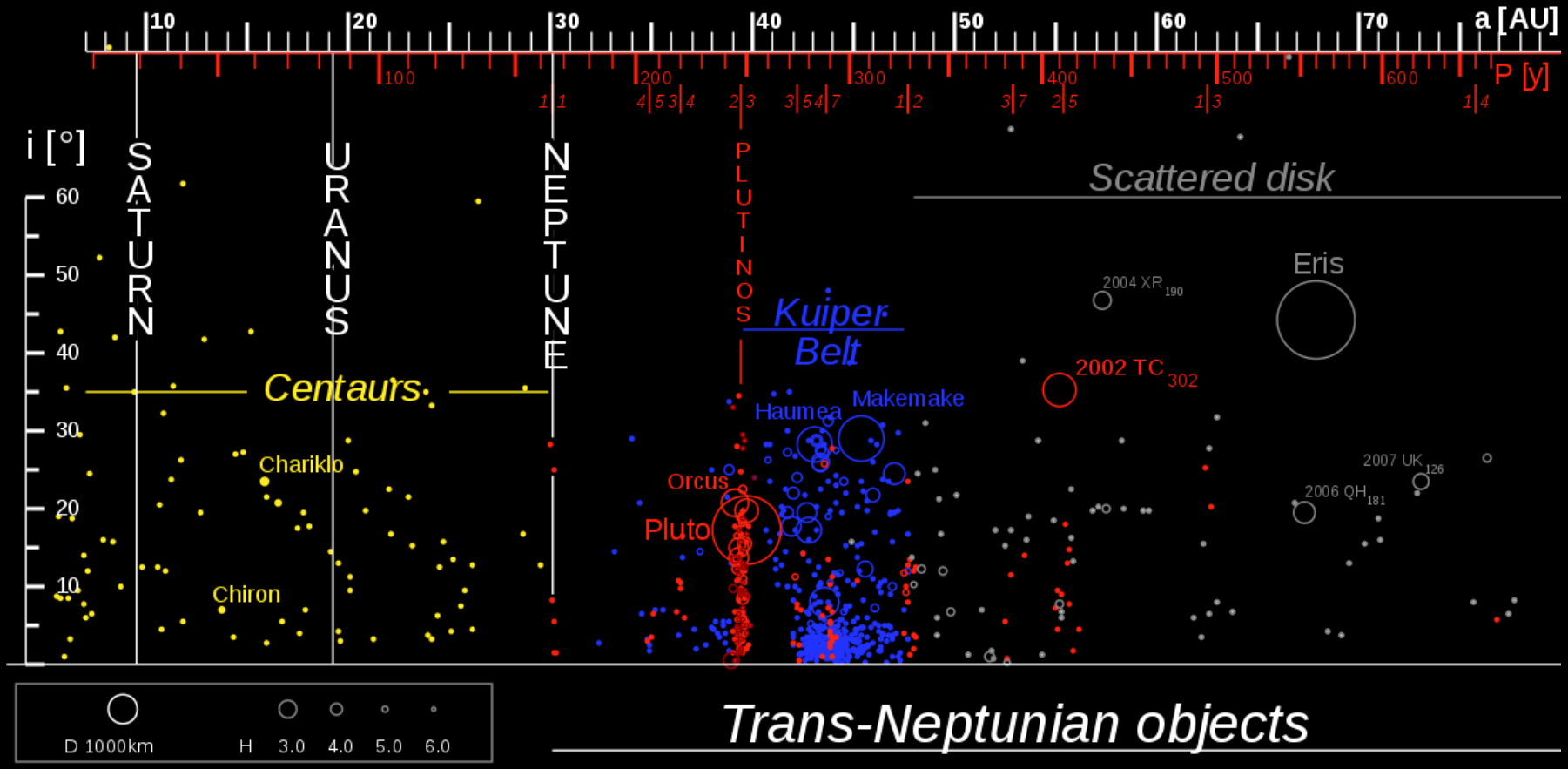
- Earth crossing asteroids, Aten and Apollo-Amor asteroids
- Trojan asteroids and Hildas, near the L4 and L5 points of Jupiter-Sun system



Trojan Asteroids and Hildas

Other Asteroids

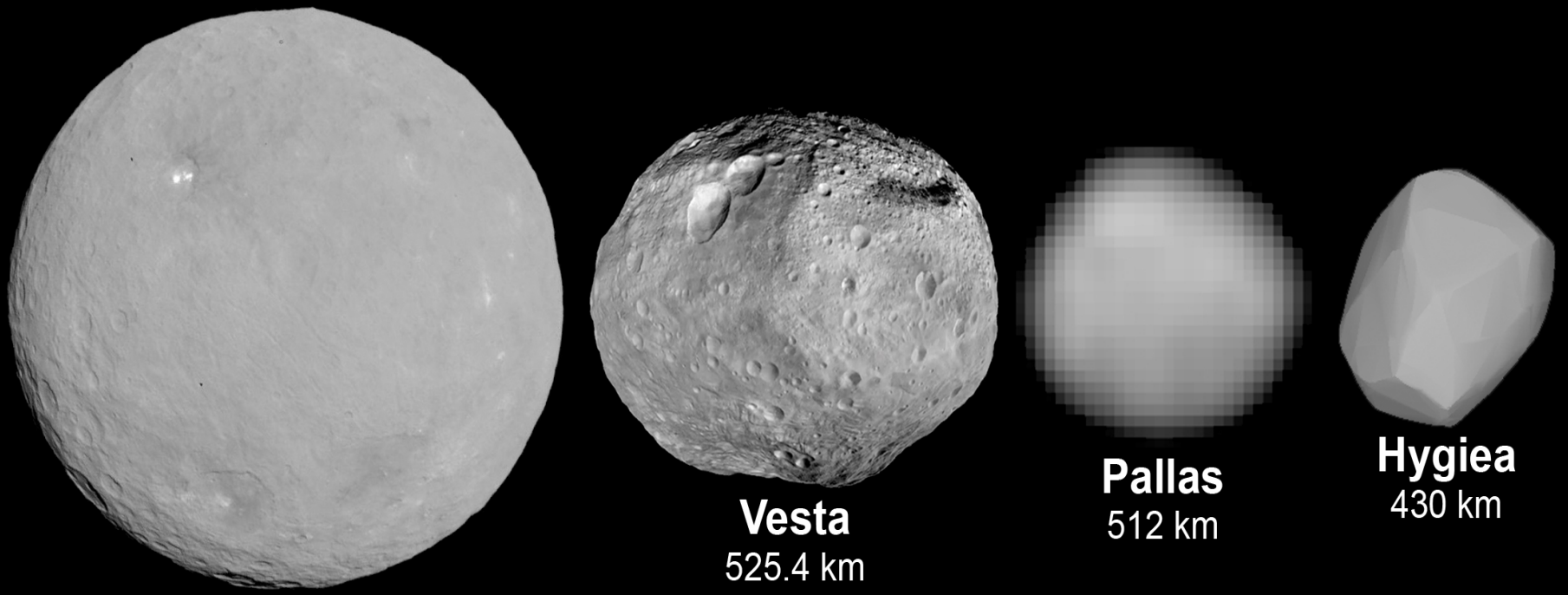
- Earth crossing asteroids, Aten and Apollo-Amor asteroids
- Trojan asteroids and Hildas, near the L4 and L5 points of Jupiter-Sun system
- Centaurs and Trans-Neptunian Objects



General Properties of Asteroids

- The largest object in the asteroid belt is the dwarf planet Ceres (946 km) with the smallest objects having radii < meters.
- Asteroids fall into three main groups defined by their chemical compositions, carbonaceous (C-type, 75 %), silicate (S-type, 17 %), and metal-rich (M-type, 7 %)
- The total mass of the bodies in the asteroid belt is only $(12.25 \pm 0.19) \times 10^{-10}\ M_{Sun} \approx 2.5\ M_{Ceres}$ much less than the mass of Pluto and, in fact, only 2 times the mass of Pluto's moon Charon

The Four Largest Asteroids

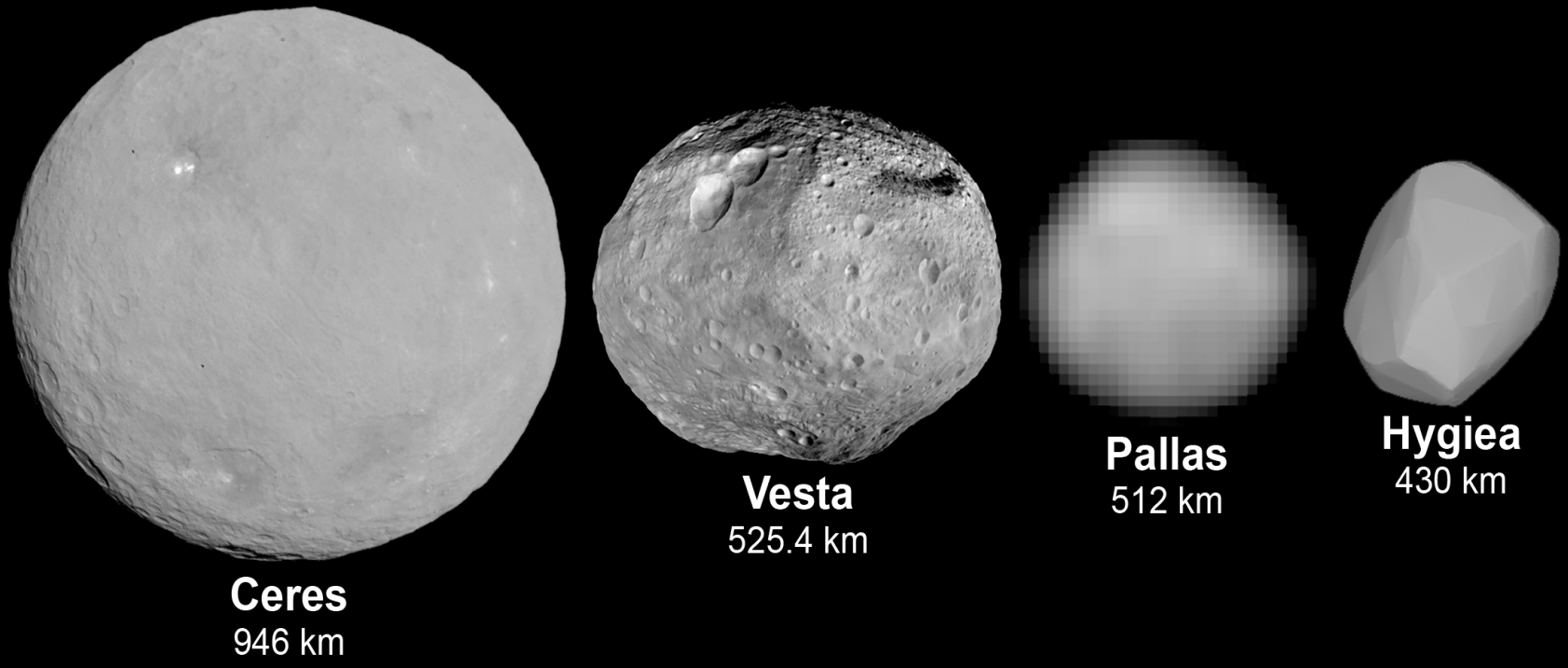


Ceres
946 km

Vesta
525.4 km

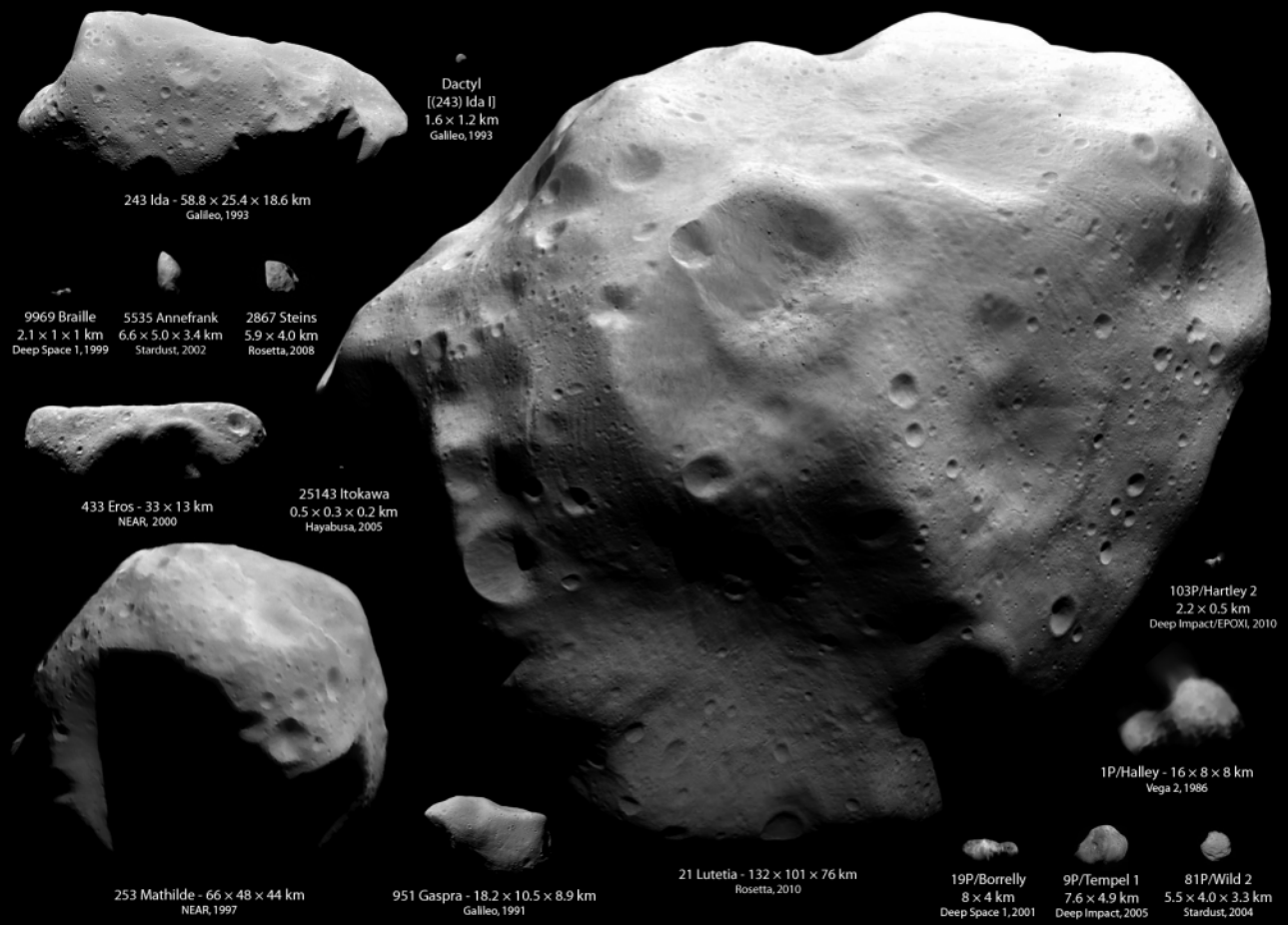
Pallas
512 km

Hygiea
430 km



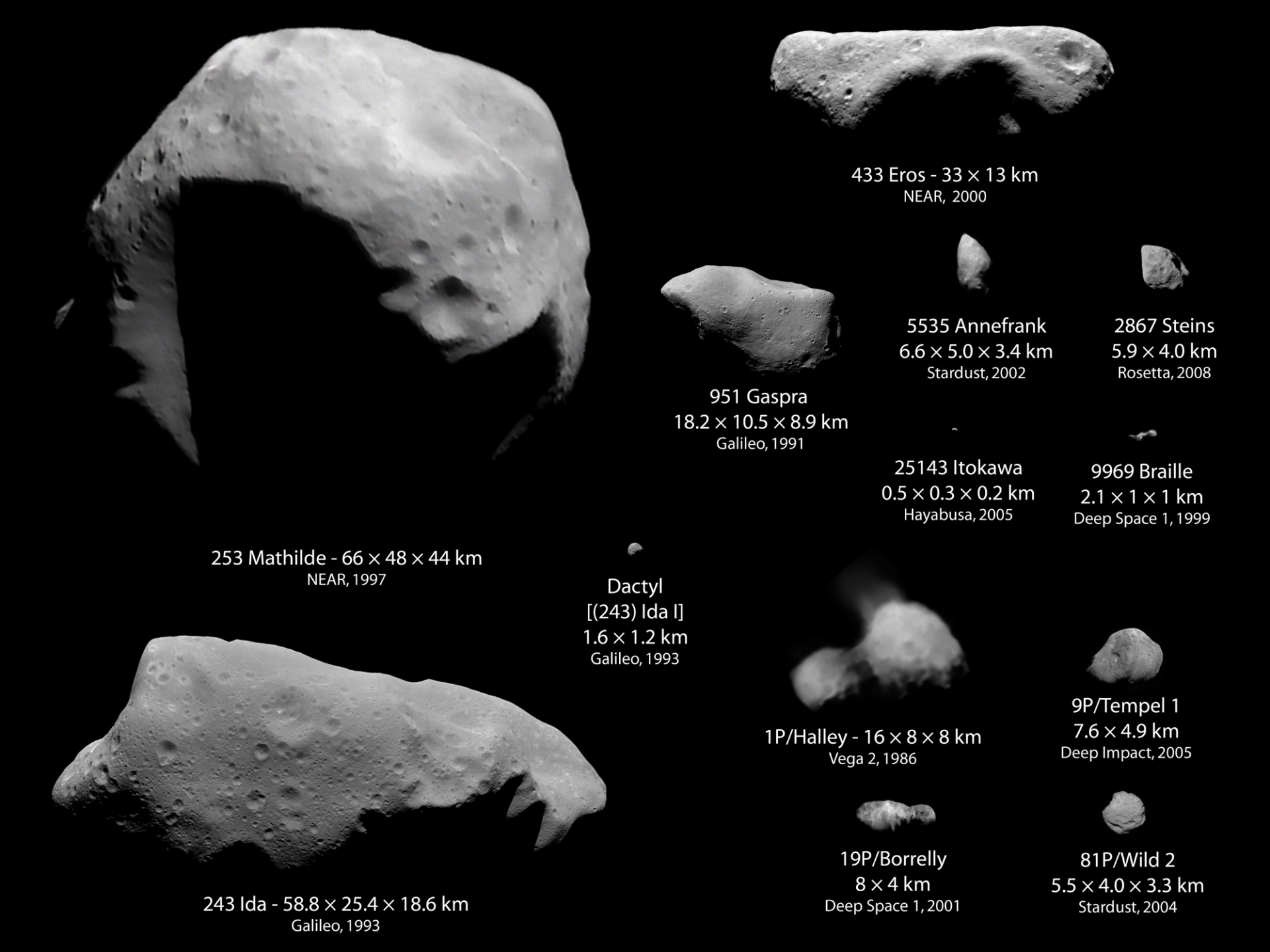
The largest asteroids are nearly spherical in shape. This suggests something about how they are held together. The largest asteroids are held together by gravity. Because gravity is isotropic in nature and acts nonlocally and the supporting pressure is also nearly isotopic, large asteroids also tend to be isotropic, that is, spherical in shape.

Small Asteroids

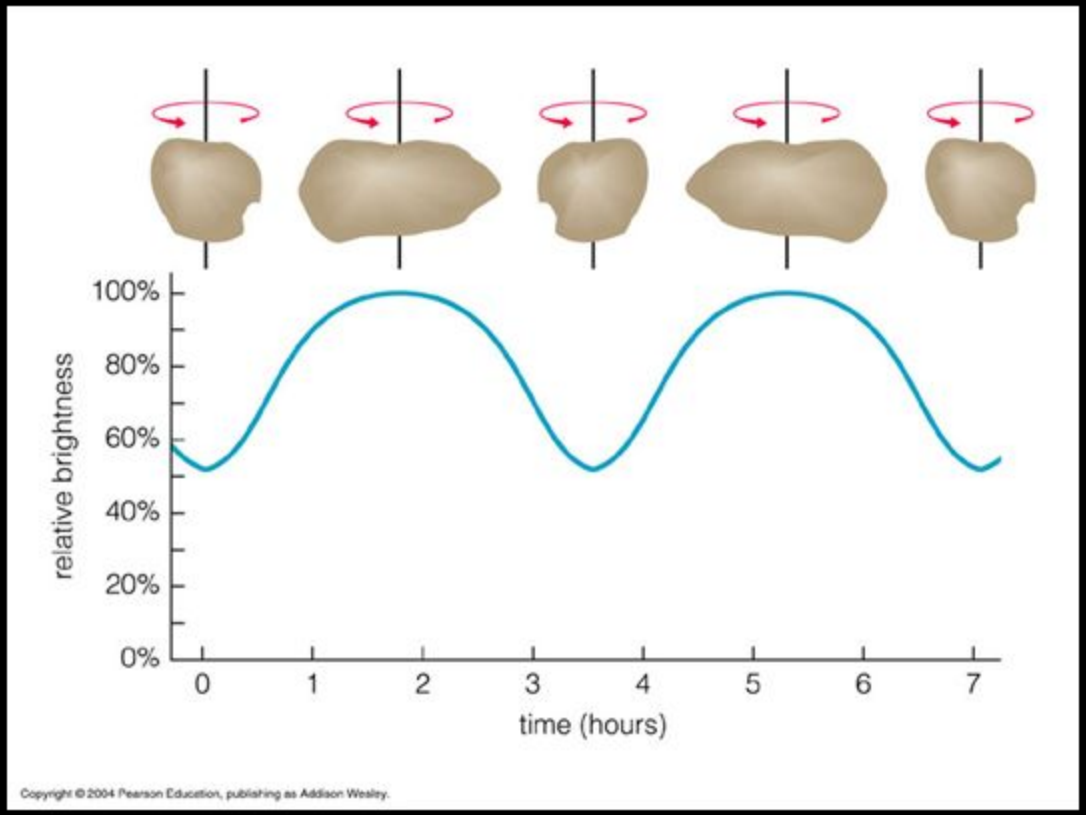


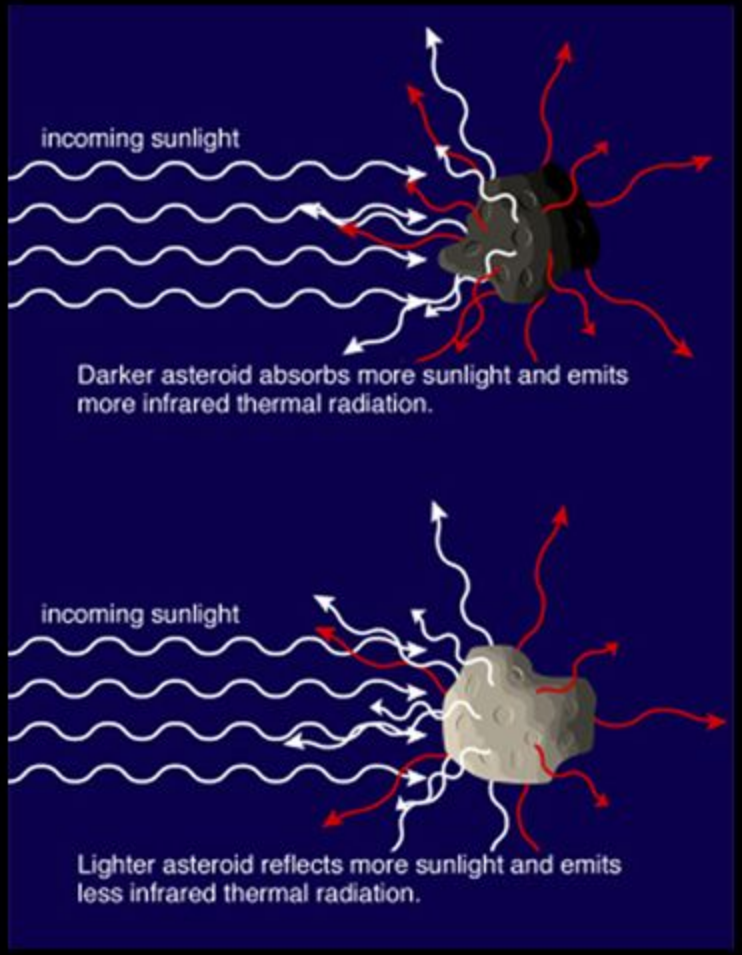
Small asteroids are not spherical in shape; Forces other than gravity affect their shapes.

Small asteroids are strongly affected by the electrical interaction between the rocks out of which they are made. Because the electrical interaction is between individual rocks (and so local), asteroids can assume nonspherical shapes.


433 Eros - 33 × 13 km
NEAR, 2000
5535 Annefrank
6.6 × 5.0 × 3.4 km
Stardust, 2002
2867 Steins
5.9 × 4.0 km
Rosetta, 2008
951 Gaspra
18.2 × 10.5 × 8.9 km
Galileo, 1991
25143 Itokawa
0.5 × 0.3 × 0.2 km
Hayabusa, 2005
9969 Braille
2.1 × 1 × 1 km
Deep Space 1, 1999
253 Mathilde - 66 × 48 × 44 km
NEAR, 1997
Dactyl
[(243) Ida I]
1.6 × 1.2 km
Galileo, 1993
1P/Halley - 16 × 8 × 8 km
Vega 2, 1986
9P/Tempel 1
7.6 × 4.9 km
Deep Impact, 2005
19P/Borrelly
8 × 4 km
Deep Space 1, 2001
81P/Wild 2
5.5 × 4.0 × 3.3 km
Stardust, 2004
243 Ida - 58.8 × 25.4 × 18.6 km
Galileo, 1993

Asteroid Light Curves: Effects of shape and surface patchiness





SHAPE EFFECT

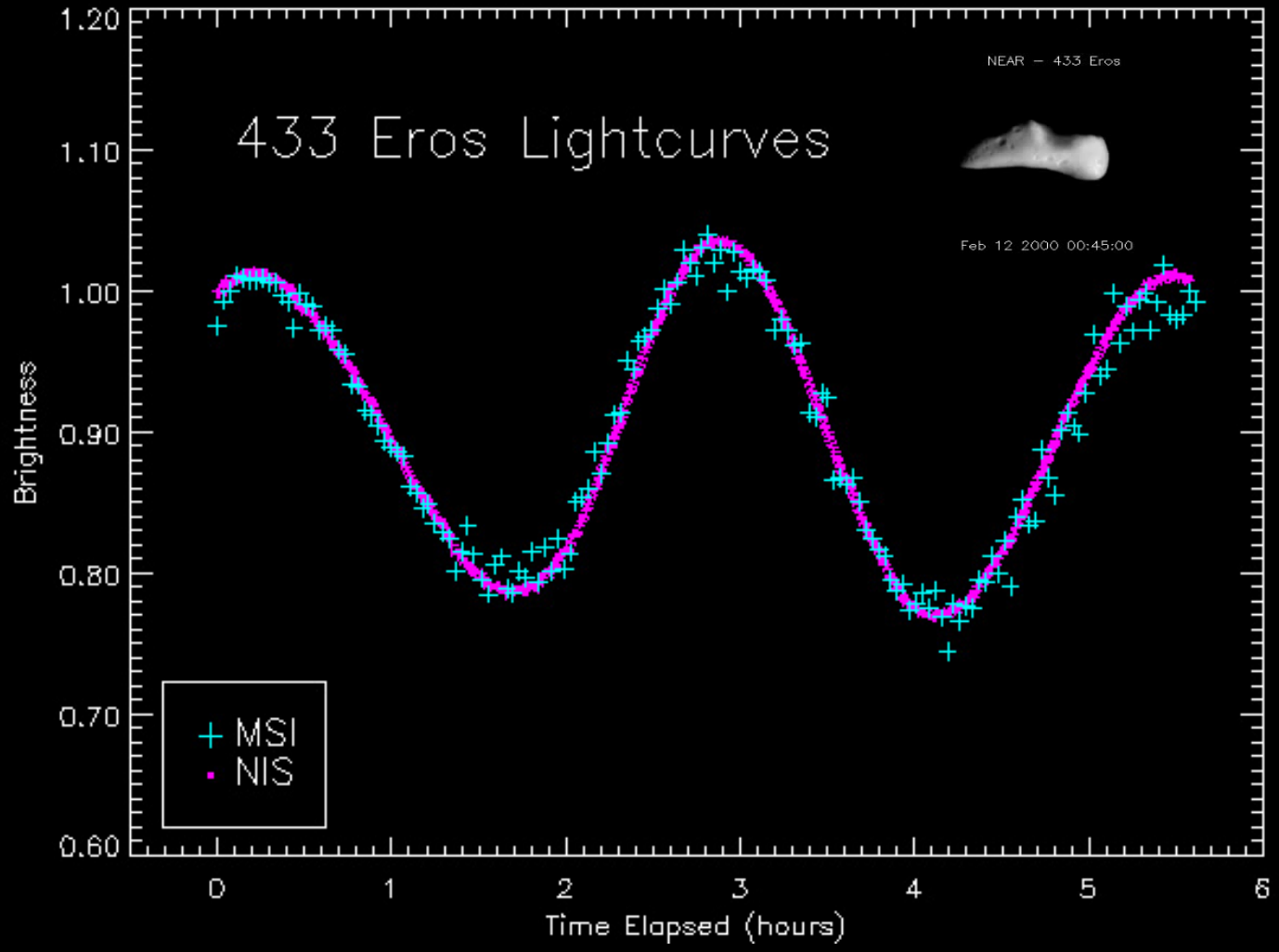
MATERIAL EFFECT

Asteroid Vesta Rotates

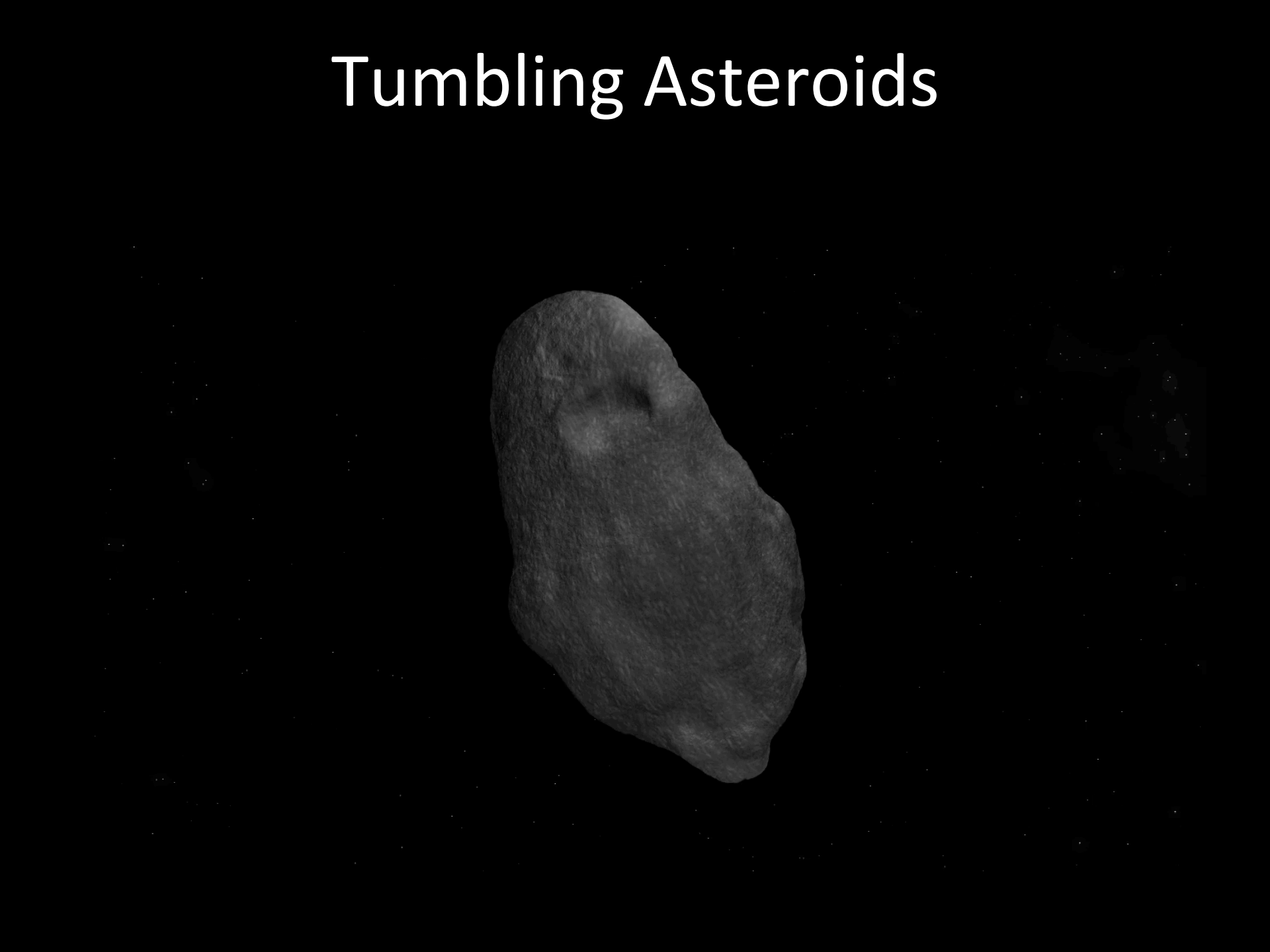
NEAR – 433 Eros

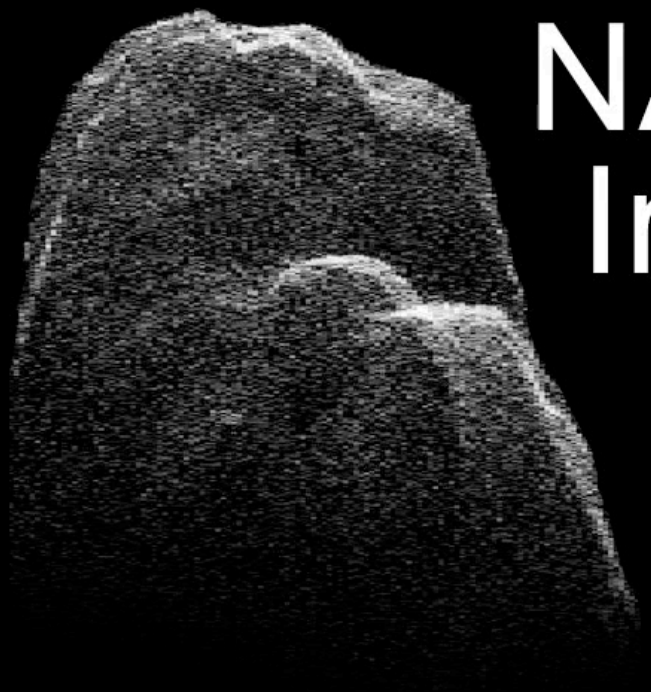
Feb 12 2000 00:45:00

433 Eros Rotational Lightcurve

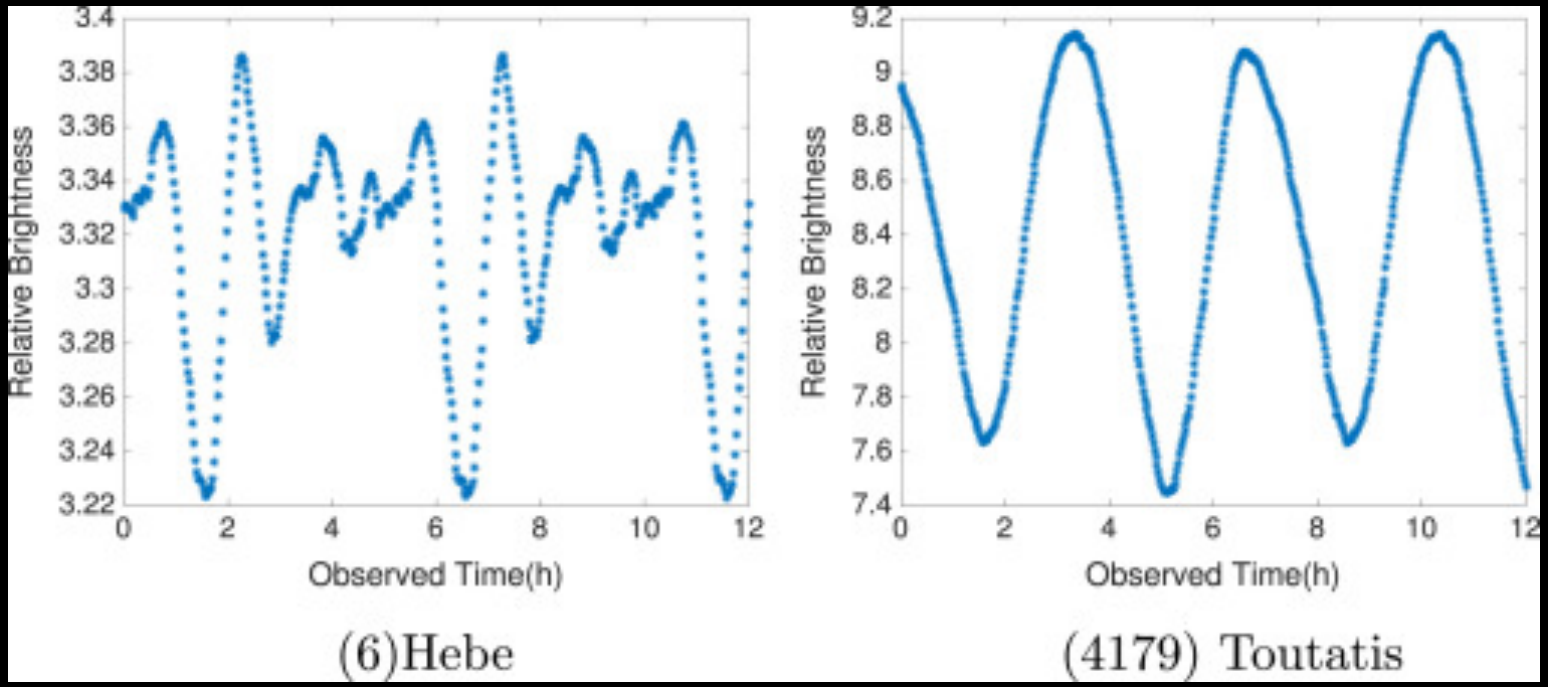


Tumbling Asteroids

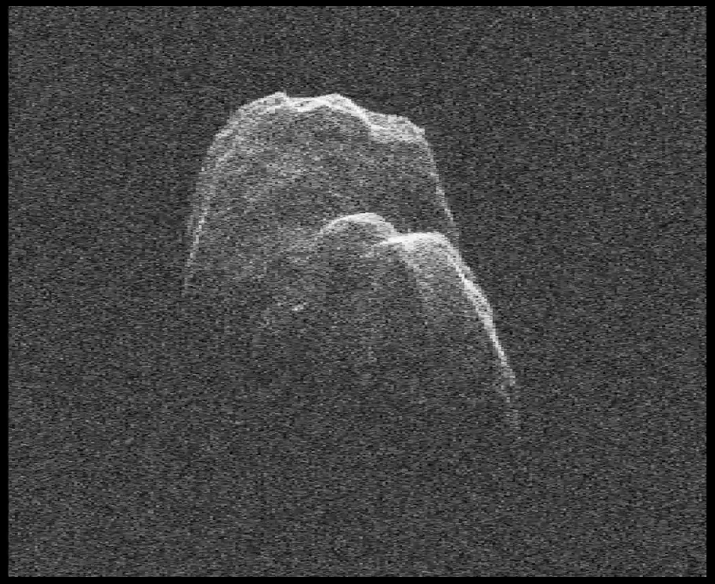




NASA Radar Images Asteroid Toutatis

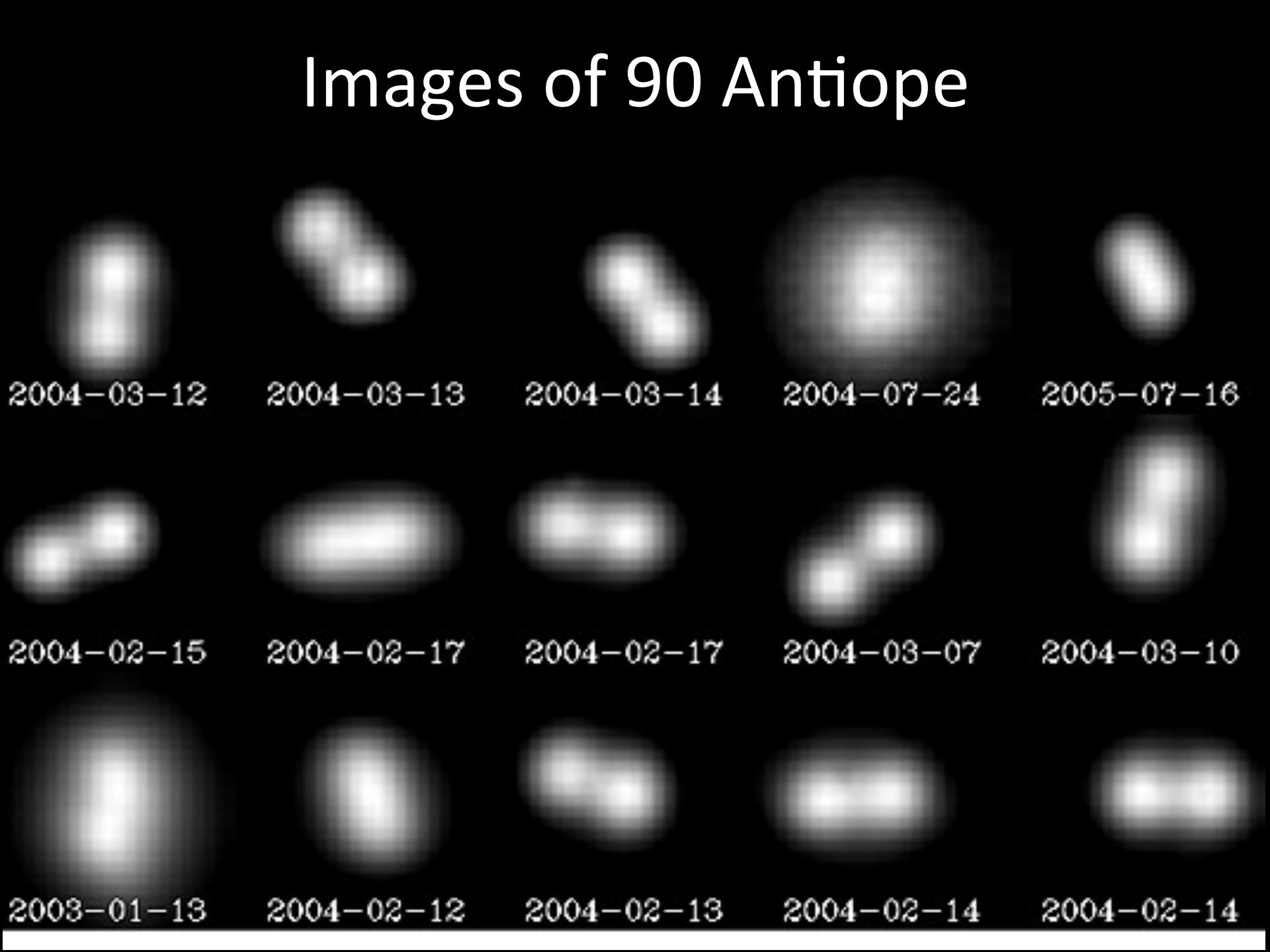


SAMPLE LIGHTCURVE:
Radar images of the Tumbler Toutatis

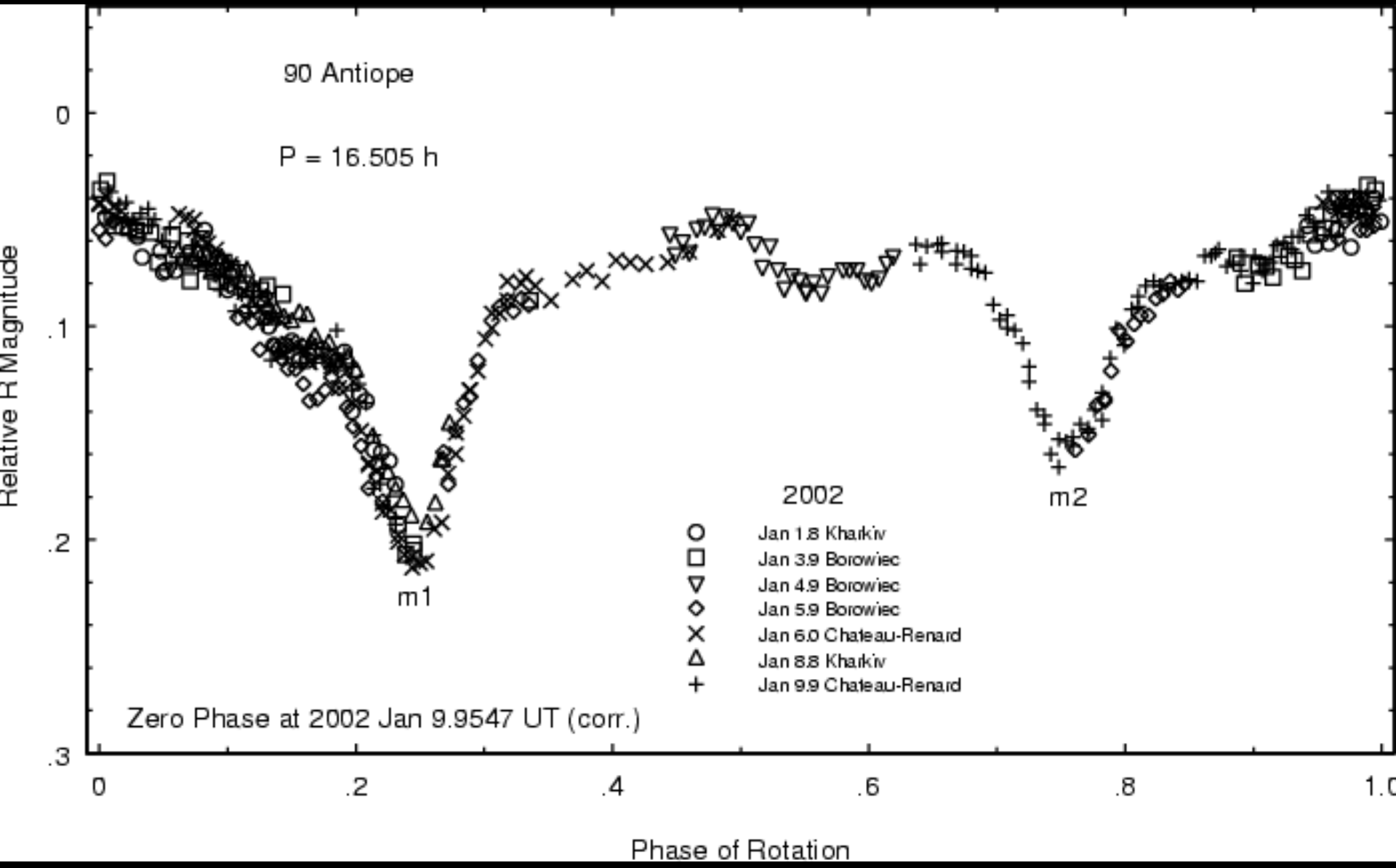


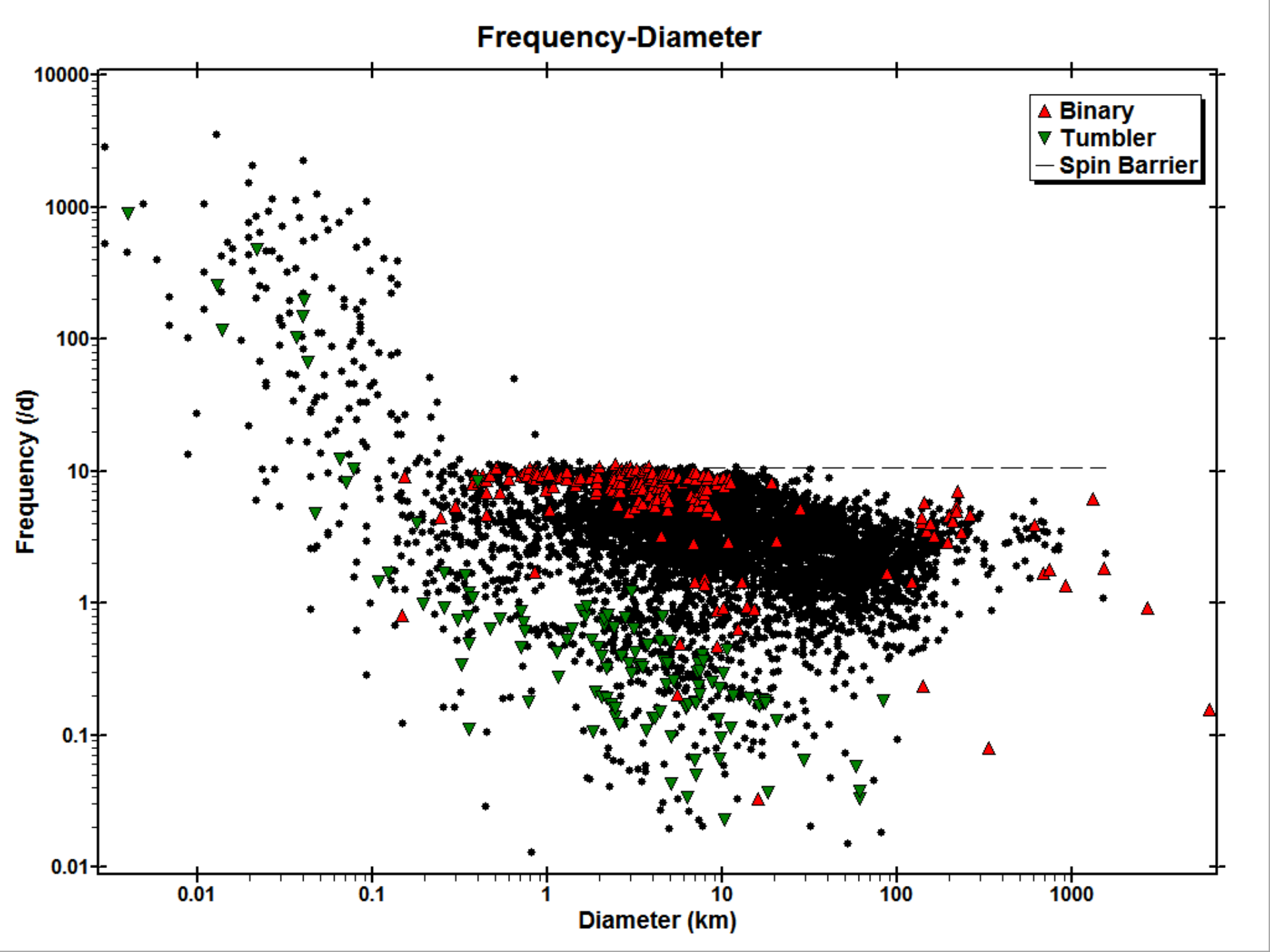
Binary Asteroids (main belt comet)

Images of 90 Antiope

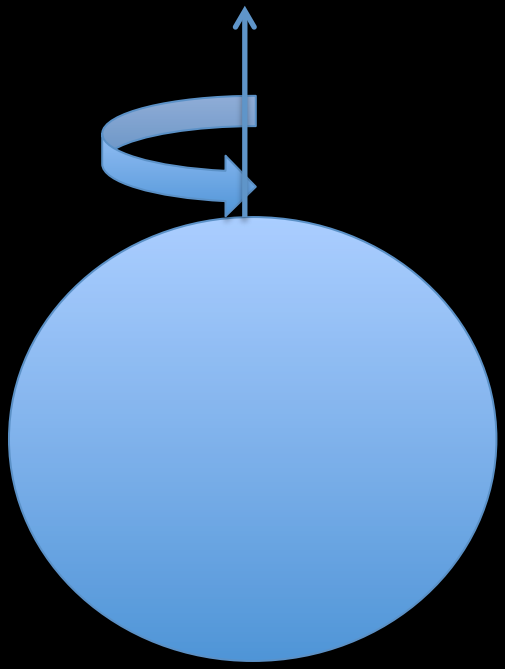


90 Antiope Orbital Lightcurve




Frequency-Diameter
Binary
Tumbler
Spin Barrier
Frequency (/d)
Diameter (km)
10000
1000
100
10
1
0.1
0.01
0.01
0.1
1
10
100
1000

Spin Barrier



FORCE BALANCE

$-mg + ma_c > 0$

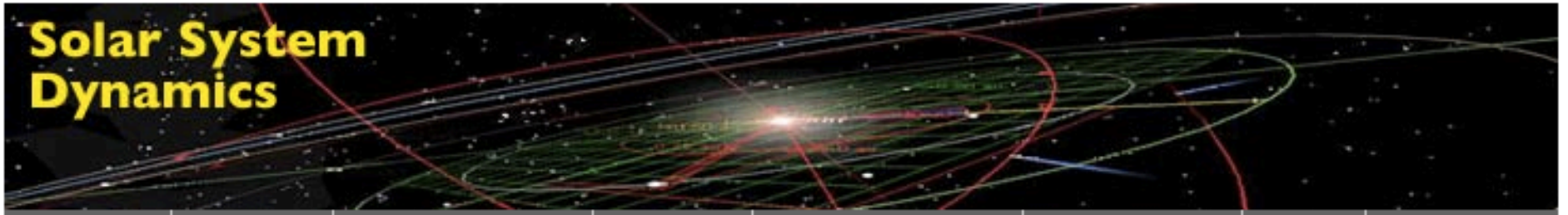
For $a_c > g$ or when

$P < 1.9\ h$,

the object is disrupted

TARGETS

	Diameter(km)	a (A.U.)	H Mag	P_{orb}(hours)	P_{rot}(hours)
Mathilde	52.8	2.649	10.3	….	417.7
Minerva	3.2,3.6	2.76	7.9	26.75,57.74	5.98
Amalthea	50.14	2.38	8.7	?	9.95
Thyra	75	2.38	7.51	?	7.24
Tokai	8.1	2.226	12.1	25.896	25.885
Bascom	5.96	2.3	12.5	43.512	2.745
Summerfield	6.25	2.6	13.0	?	2.59
Elektra	215	3.13	7.12	26.4,126.2	5.225



JPL Small-Body Database Browser

Search: [help]

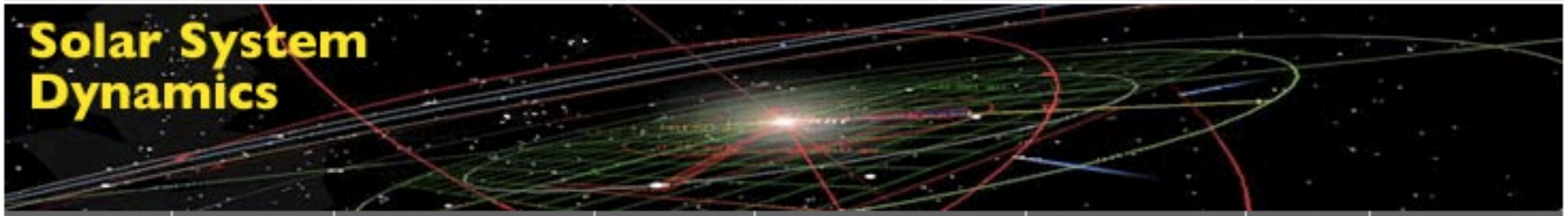
Introduction/Overview

Enter the IAU number, name, or designation for the object of interest in the **Search** form above. For example, to display information about asteroid 433 Eros, you can enter either "**433**" or "**eros**" (names are not case-sensitive). Detailed instructions are available via the help link.

The **JPL Small-Body Database Browser** provides data for all known asteroids and many comets. Available data include:

- orbital elements
- orbit diagrams
- physical parameters
- discovery circumstances

Newly discovered objects and their orbits are added on a daily basis. Discovery circumstances are updated on a roughly monthly interval. Physical parameters, other than magnitude parameters, are updated on a less frequent basis.



JPL Small-Body Database Browser

Search: [help]

253 Mathilde

Enter name

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253 Mathilde

JPL Small-Body Database Browser Search: [help]

253 Mathilde

Classification: Main-belt Asteroid **SPK-ID:** 2000253

[Ephemeris | Orbit Diagram | Orbital Elements | Mission Design | Physical Parameters | Discovery Circumstances | Close-Approach Data]

[show orbit diagram]

Orbital Elements at Epoch 2458200.5 (2018-Mar-23.0) TDB
Reference: JPL 203 (heliocentric ecliptic J2000)

Element	Value	Uncertainty (1-sigma)	Units
e	.2628963240363099	2.1681e-08	
a	2.649176776917755	6.7195e-09	au
q	1.952717940543718	5.5754e-08	au
i	6.738883806970743	3.7163e-06	deg
node	179.5612281667418	1.9311e-05	deg
peri	157.6181678076346	1.9673e-05	deg
M	307.298269745621	7.0464e-06	deg
t_p	2458431.061722929206 (2018-Nov-08.56172293)	3.1448e-05	JED
period	1574.942982970041	5.9922e-06	d
	4.31	1.641e-08	yr
n	.2285797034513014	8.6967e-10	deg/d
Q	3.345635613291792	8.4861e-09	au

Orbit Determination Parameters

# obs. used (total)	3284
# delay obs. used	1
# Doppler obs. used	0
data-arc span	48382 days (132.46 yr)
first obs. used	1885-12-01
last obs. used	2018-05-20
planetary ephem.	DE431
SB-pert. ephem.	SB431-N16
condition code	0
fit RMS	.48543
data source	ORB
producer	Otto Matic
solution date	2018-May-31 11:49:38

Additional Information

Earth MOID = .944773 au
Jupiter MOID = 2.06884 au
T_jup = 3.331

[show covariance matrix]

[Ephemeris | Orbit Diagram | Orbital Elements | Mission Design | Physical Parameters | Discovery Circumstances | Close-Approach Data]

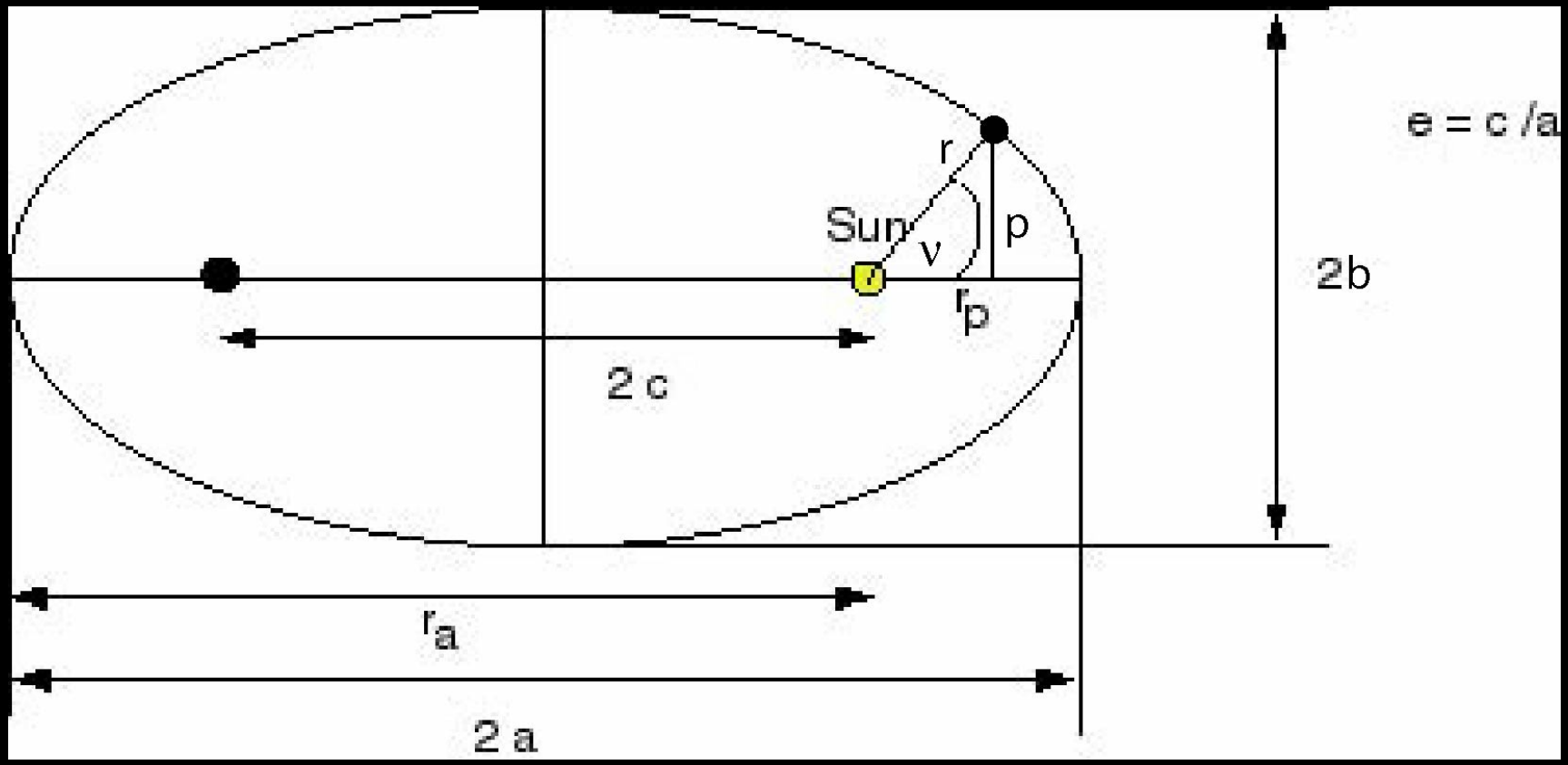
Physical Parameter Table

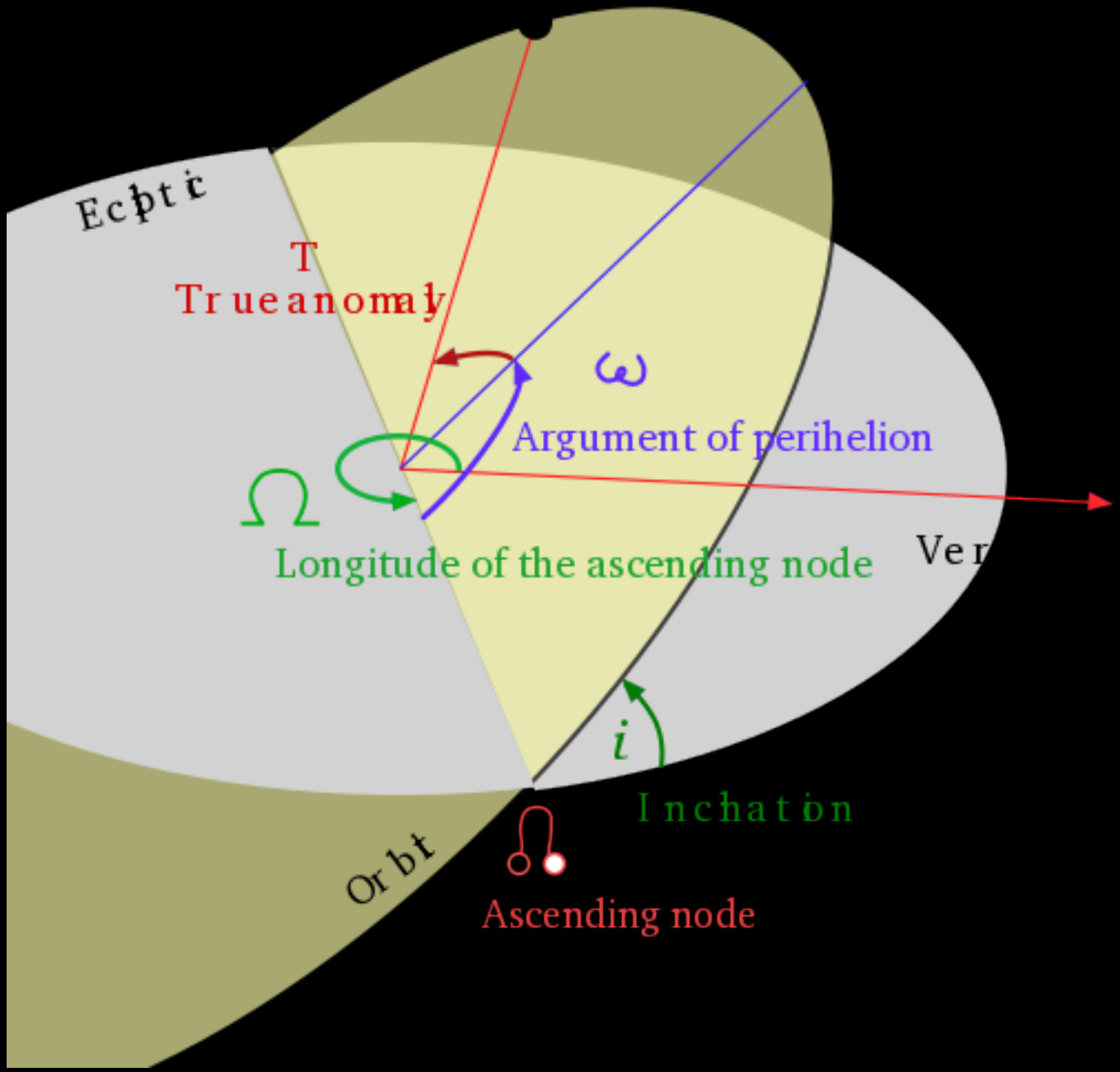
Parameter	Symbol	Value	Units	Sigma	Reference	Notes
absolute magnitude	H	10.3	mag	n/a	MPO267706	
diameter	diameter	52.8	km	n/a	n/a	Yeomans E-mail 2001-Apr-04
GM	GM	0.00689	km^3/s^2	0.00030	Yeomans et al. (1997) Science v.278, pp.2106-2109	
bulk density	density	1.3	g/cm^3	0.2	Yeomans et al. (1997) Science v.278, pp.2106-2109	based on a nominal volume of 78000 km^3 (with lower/uppper limits of 67000/90000 km^3)
rotation period	rot_per	417.7	h	n/a	LCDB (Rev. 2018-June); Warner et al., 2009	**Published Reference List:** [Mottola, S.; Sears, W.D.; Erikson, A.; Harris, A.W.; et al. (1995) Planet. Space Sci. 43, 1609-1613.] [Pravec, P.; et al. (2005) Icarus 173, 108-131.]
geometric albedo	albedo	0.0436		0.004	IRAS-A-FPA-3-RDR-IMPS-V6.0	IRAS observations used: 20
SMASSII spectral type	spec_B	Cb		n/a	EAR-A-5-DDR-TAXONOMY-V4.0	based on a high-resolution spectrum by Xu et al. (1995) or Bus and Binzel (2002)

253 Mathilde Discovered 1885-Nov-12 by Palisa, J. at Vienna

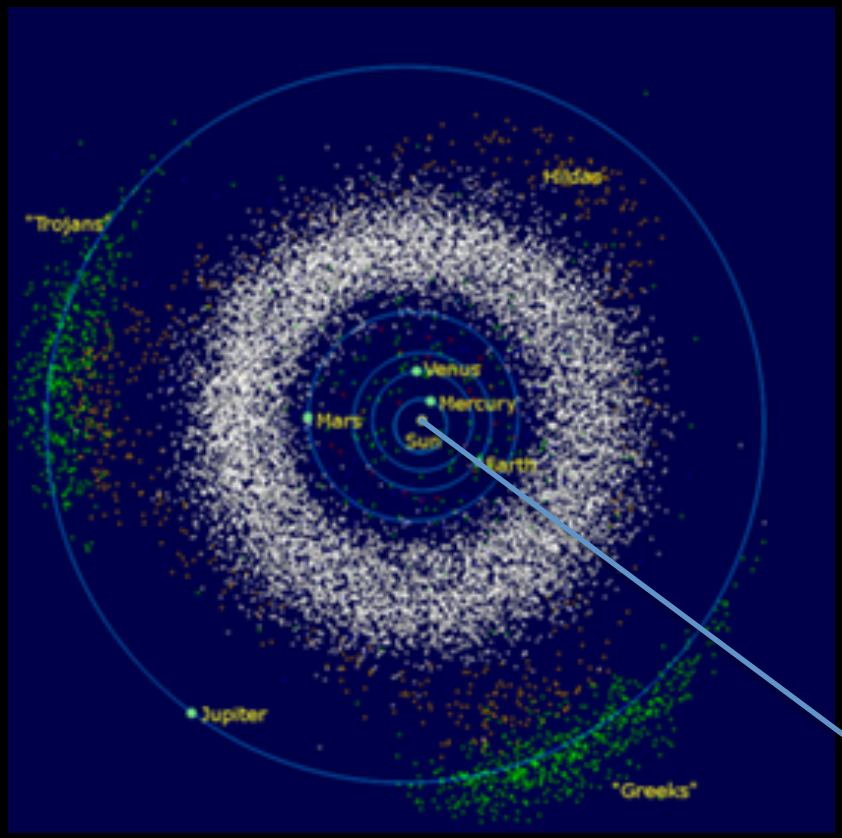
sa.gov/sbdb.cgi?sstr=Mathilde;old=0;orb=0;cov=0;log=0;cad=0#phys_par 2003-08-29

Orbital Elements




Ecliptic
T
True anomaly
ω
Argument of perihelion
Ω
Longitude of the ascending node
Ver
i
Inclination
Orbit
Ascending node

Observing Targets: Asteroids

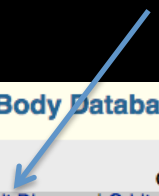


- When asteroids are on the opposite side of the Sun from the Earth, they are at opposition.
- At opposition, main belt asteroids (MBAs) are closest to the Earth and so are the brightest and thus at the best positions in which to make observations.

Asteroids at opposition fall along this line

253 Mathilde

Click here



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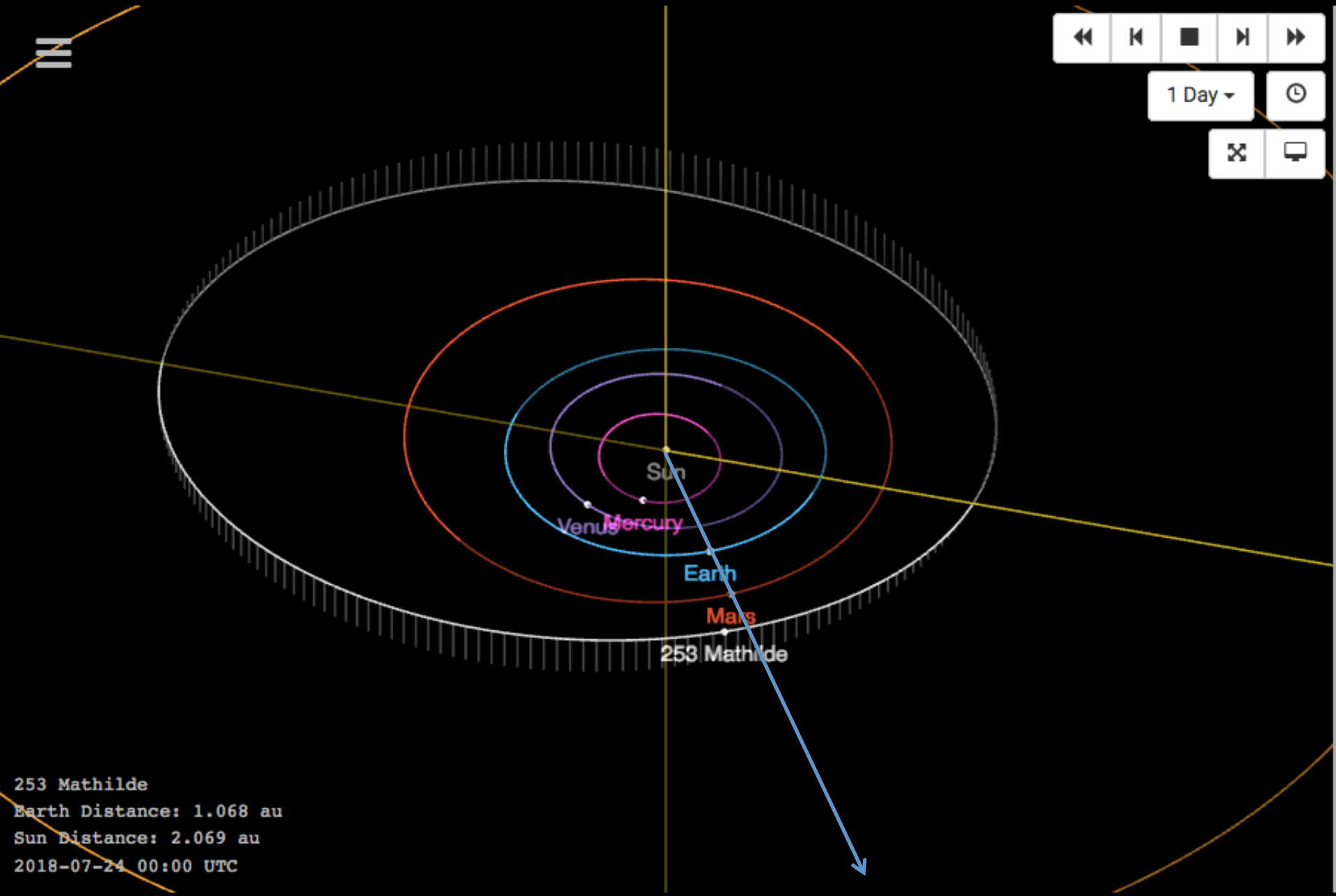
bulk density	density	1.3	g/cm^3	0.2	Yeomans et al. (1997) Science v.278, pp.2106-2109	based on a nominal volume of 78000 km^3 (with lower/uppper limits of 67000/90000 km^3)
rotation period	rot_per	417.7	h	n/a	LCDB (Rev. 2018-June); Warner et al., 2009	**Published Reference List:** [Mottola, S.; Sears, W.D.; Erikson, A.; Harris, A.W.; et al. (1995) Planet. Space Sci. 43, 1609-1613.] [Pravec, P.; et al. (2005) Icarus 173, 108-131.]
geometric albedo	albedo	0.0436		0.004	IRAS-A-FPA-3-RDR-IMPS-V6.0	IRAS observations used: 20
SMASSII spectral type	spec_B	Cb		n/a	EAR-A-5-DDR-TAXONOMY-V4.0	based on a high-resolution spectrum by Xu et al. (1995) or Bus and Binzel (2002)

253 Mathilde Discovered 1885-Nov-12 by Palisa, J. at Vienna

sa.gov/sbdb.cgi?sstr=Mathilde;old=0;orb=0;cov=0;log=0;cad=0#phys_par 2003-08-29


1 Day
Sun
Venus
Mercury
Earth
Mars
253 Mathilde
253 Mathilde
Earth Distance: 1.068 au
Sun Distance: 2.069 au
2018-07-24 00:00 UTC

253 Mathilde

JPL Small-Body Database Browser Search: [help]

253 Mathilde

Classification: Main-belt Asteroid **SPK-ID:** 2000253

[Ephemeris | Orbit Diagram | Orbital Elements | Mission Design | Physical Parameters | Discovery Circumstances | Close-Approach Data]

[show orbit diagram]

Orbital Elements at Epoch 2458200.5 (2018-Mar-23.0) TDB
Reference: JPL 203 (heliocentric ecliptic J2000)

Element	Value	Uncertainty (1-sigma)	Units
e	.2628963240363099	2.1681e-08	
a	2.649176776917755	6.7195e-09	au
q	1.952717940543718	5.5754e-08	au
i	6.738883806970743	3.7163e-06	deg
node	179.5612281667418	1.9311e-05	deg
peri	157.6181678076346	1.9673e-05	deg
M	307.298269745621	7.0464e-06	deg
t_p	2458431.061722929206 (2018-Nov-08.56172293)	3.1448e-05	JED
period	1574.942982970041	5.9922e-06	d
	4.31	1.641e-08	yr
n	.2285797034513014	8.6967e-10	deg/d
Q	3.345635613291792	8.4861e-09	au

Orbit Determination Parameters

# obs. used (total)	3284
# delay obs. used	1
# Doppler obs. used	0
data-arc span	48382 days (132.46 yr)
first obs. used	1885-12-01
last obs. used	2018-05-20
planetary ephem.	DE431
SB-pert. ephem.	SB431-N16
condition code	0
fit RMS	.48543
data source	ORB
producer	Otto Matic
solution date	2018-May-31 11:49:38

Additional Information

Earth MOID = .944773 au
Jupiter MOID = 2.06884 au
T_jup = 3.331

[show covariance matrix]

Click on Ephemeris

[Ephemeris | Orbit Diagram | Orbital Elements | Mission Design | Physical Parameters | Discovery Circumstances | Close-Approach Data]

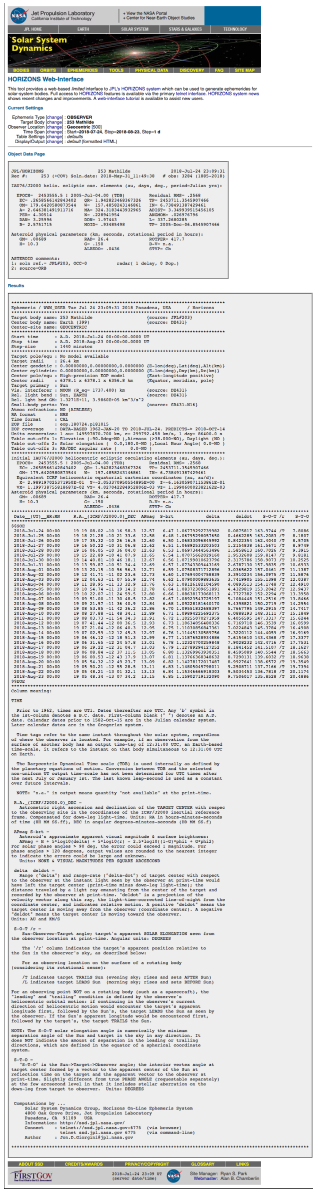
Physical Parameter Table

Parameter	Symbol	Value	Units	Sigma	Reference	Notes
absolute magnitude	H	10.3	mag	n/a	MPO267706	
diameter	diameter	52.8	km	n/a	n/a	Yeomans E-mail 2001-Apr-04
GM	GM	0.00689	km^3/s^2	0.00030	Yeomans et al. (1997) Science v.278, pp.2106-2109	
bulk density	density	1.3	g/cm^3	0.2	Yeomans et al. (1997) Science v.278, pp.2106-2109	based on a nominal volume of 78000 km^3 (with lower/uppper limits of 67000/90000 km^3)
rotation period	rot_per	417.7	h	n/a	LCDB (Rev. 2018-June); Warner et al., 2009	**Published Reference List:** [Mottola, S.; Sears, W.D.; Erikson, A.; Harris, A.W.; et al. (1995) Planet. Space Sci. 43, 1609-1613.] [Pravec, P.; et al. (2005) Icarus 173, 108-131.]
geometric albedo	albedo	0.0436		0.004	IRAS-A-FPA-3-RDR-IMPS-V6.0	IRAS observations used: 20
SMASSII spectral type	spec_B	Cb		n/a	EAR-A-5-DDR-TAXONOMY-V4.0	based on a high-resolution spectrum by Xu et al. (1995) or Bus and Binzel (2002)

253 Mathilde Discovered 1885-Nov-12 by Palisa, J. at Vienna

sa.gov/sbdb.cgi?sstr=Mathilde;old=0;orb=0;cov=0;log=0;cad=0#phys_par 2003-08-29

Asteroid Ephemerides



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HORIZONS Web-Interface

This tool provides a web-based *limited* interface to JPL's HORIZONS system which can be used to generate ephemerides for solar-system bodies. Full access to HORIZONS features is available via the primary telnet interface. HORIZONS system news shows recent changes and improvements. A web-interface tutorial is available to assist new users.

Current Settings

Ephemeris Type [change] : **OBSERVER**
Target Body [change] : **253 Mathilde**
Observer Location [change] : **Geocentric** [500]
Time Span [change] : Start=**2018-07-24**, Stop=**2018-08-23**, Step=**1 d**
Table Settings [change] : *defaults*
Display/Output [change] : *default* (formatted HTML)

Object Data Page

```
JPL/HORIZONS                      253 Mathilde              2018-Jul-24 23:09:31
Rec #:     253 (+COV) Soln.date: 2018-May-31_11:49:38   # obs: 3284 (1885-2018)

IAU76/J2000 helio. ecliptic osc. elements (au, days, deg., period=Julian yrs):

  EPOCH=  2453555.5 ! 2005-Jul-04.00 (TDB)         Residual RMS= .2568
   EC= .2658566142843402   QR= 1.942823468367326   TP= 2453711.3545907466
   OM= 179.6420580873544   W=  157.4858243146861   IN= 6.738491387429461
   A= 2.646381491911716    MA= 324.3183443932965   ADIST= 3.349939515456105
   PER= 4.30514            N= .228941954           ANGMOM= .026976796
   DAN= 3.25996            DDN= 1.97443            L= 337.2680285
   B= 2.5751715            MOID= .93485498         TP= 2005-Dec-06.8545907466

Asteroid physical parameters (km, seconds, rotational period in hours):
   GM= .00689              RAD= 26.4               ROTPER= 417.7
   H= 10.3                 G= .150                 B-V= n.a.
                           ALBEDO= .0436           STYP= Cb

ASTEROID comments:
1: soln ref.= JPL#203, OCC=0           radar( 1 delay, 0 Dop.)
2: source=ORB
```

Results

```
*******************************************************************************
Ephemeris / WWW_USER Tue Jul 24 23:09:31 2018 Pasadena, USA      / Horizons
*******************************************************************************
Target body name: 253 Mathilde                    {source: JPL#203}
Center body name: Earth (399)                     {source: DE431}
Center-site name: GEOCENTRIC
*******************************************************************************
Start time      : A.D. 2018-Jul-24 00:00:00.0000 UT
Stop  time      : A.D. 2018-Aug-23 00:00:00.0000 UT
Step-size       : 1440 minutes
*******************************************************************************
Target pole/equ : No model available
Target radii    : 26.4 km
Center geodetic : 0.00000000,0.00000000,0.0000000 {E-lon(deg),Lat(deg),Alt(km)}
Center cylindric: 0.00000000,0.00000000,0.0000000 {E-lon(deg),Dxy(km),Dz(km)}
Center pole/equ : High-precision EOP model        {East-longitude positive}
Center radii    : 6378.1 x 6378.1 x 6356.8 km     {Equator, meridian, pole}
Target primary  : Sun
Vis. interferer : MOON (R_eq= 1737.400) km        {source: DE431}
Rel. light bend : Sun, EARTH                      {source: DE431}
Rel. lght bnd GM: 1.3271E+11, 3.9860E+05 km^3/s^2
Small-body perts: Yes                             {source: SB431-N16}
Atmos refraction: NO (AIRLESS)
RA format       : HMS
Time format     : CAL
EOP file        : eop.180724.p181015
EOP coverage    : DATA-BASED 1962-JAN-20 TO 2018-JUL-24. PREDICTS-> 2018-OCT-14
Units conversion: 1 au= 149597870.700 km, c= 299792.458 km/s, 1 day= 86400.0 s
Table cut-offs 1: Elevation (-90.0deg=NO ),Airmass (>38.000=NO), Daylight (NO )
Table cut-offs 2: Solar elongation (  0.0,180.0=NO ),Local Hour Angle( 0.0=NO )
Table cut-offs 3: RA/DEC angular rate (     0.0=NO )
*******************************************************************************
Initial IAU76/J2000 heliocentric ecliptic osculating elements (au, days, deg.):
  EPOCH=  2453555.5 ! 2005-Jul-04.00 (TDB)         Residual RMS= .2568
   EC= .2658566142843402   QR= 1.942823468367326   TP= 2453711.3545907466
   OM= 179.6420580873544   W=  157.4858243146861   IN= 6.738491387429461
  Equivalent ICRF heliocentric equatorial cartesian coordinates (au, au/d):
   X= 2.989197025371950E-01  Y=-2.053370950554895E+00  Z=-6.163059071153861E-01
  VX= 1.199738755818687E-02 VY= 4.027042284952806E-03 VZ= 1.199060002382162E-03
Asteroid physical parameters (km, seconds, rotational period in hours):
   GM= .00689              RAD= 26.4               ROTPER= 417.7
   H= 10.3                 G= .150                 B-V= n.a.
                           ALBEDO= .0436           STYP= Cb
*******************************************************************************************************
 Date__(UT)__HR:MN     R.A._(ICRF/J2000.0)_DEC  APmag  S-brt             delta      deldot    S-O-T /r    S-T-O
*******************************************************************************************************
$$SOE
 2018-Jul-24 00:00     19 19 08.02 -10 16 58.3  12.57   6.47 1.06779292739982   0.0875817 163.9744 /T   7.8086
 2018-Jul-25 00:00     19 18 21.28 -10 21 33.6  12.58   6.48 1.06795298057650   0.4662285 163.2083 /T   8.1807
 2018-Jul-26 00:00     19 17 35.32 -10 26 16.5  12.60   6.50 1.06833096845992   0.8422354 162.4040 /T   8.5705
 2018-Jul-27 00:00     19 16 50.22 -10 31 06.8  12.62   6.51 1.06892533203503   1.2154838 161.5671 /T   8.9749
 2018-Jul-28 00:00     19 16 06.05 -10 36 04.0  12.63   6.53 1.06973444563496   1.5858613 160.7026 /T   9.3915
 2018-Jul-29 00:00     19 15 22.89 -10 41 07.9  12.65   6.54 1.07075662029160   1.9532608 159.8147 /T   9.8181
 2018-Jul-30 00:00     19 14 40.81 -10 46 18.1  12.67   6.56 1.07199010623796   2.3175786 158.9073 /T  10.2525
 2018-Jul-31 00:00     19 13 59.87 -10 51 34.4  12.69   6.57 1.07343309443169   2.6787130 157.9835 /T  10.6933
 2018-Aug-01 00:00     19 13 20.15 -10 56 56.3  12.71   6.59 1.07508371712896   3.0365622 157.0461 /T  11.1387
 2018-Aug-02 00:00     19 12 41.71 -11 02 23.6  12.73   6.60 1.07694004758839   3.3910234 156.0975 /T  11.5876
 2018-Aug-03 00:00     19 12 04.63 -11 07 55.9  12.74   6.62 1.07900009883635   3.7419905 155.1398 /T  12.0387
 2018-Aug-04 00:00     19 11 28.95 -11 13 32.9  12.76   6.63 1.08126182104590   4.0893513 154.1748 /T  12.4910
 2018-Aug-05 00:00     19 10 54.74 -11 19 14.2  12.78   6.64 1.08372309651891   4.4329819 153.2042 /T  12.9437
 2018-Aug-06 00:00     19 10 22.07 -11 24 59.5  12.80   6.66 1.08638173068113   4.7727382 152.2294 /T  13.3958
 2018-Aug-07 00:00     19 09 51.00 -11 30 48.5  12.82   6.67 1.08923543725197   5.1084448 151.2516 /T  13.8466
 2018-Aug-08 00:00     19 09 21.57 -11 36 40.9  12.84   6.68 1.09228181640170   5.4398821 150.2719 /T  14.2954
 2018-Aug-09 00:00     19 08 53.85 -11 42 36.2  12.86   6.70 1.09551832688397   5.7667795 149.2915 /T  14.7417
 2018-Aug-10 00:00     19 08 27.88 -11 48 34.1  12.89   6.71 1.09894225692375   6.0888193 148.3111 /T  15.1849
 2018-Aug-11 00:00     19 08 03.73 -11 54 34.3  12.91   6.72 1.10255070271959   6.4056595 147.3317 /T  15.6244
 2018-Aug-12 00:00     19 07 41.44 -12 00 36.5  12.93   6.73 1.10634056480336   6.7169718 146.3539 /T  16.0599
 2018-Aug-13 00:00     19 07 21.04 -12 06 40.3  12.95   6.75 1.11030856847361   7.0224843 145.3784 /T  16.4908
 2018-Aug-14 00:00     19 07 02.59 -12 12 45.3  12.97   6.76 1.11445130589756   7.3220112 144.4059 /T  16.9169
 2018-Aug-15 00:00     19 06 46.12 -12 18 51.3  12.99   6.77 1.11876528934886   7.6154610 143.4368 /T  17.3377
 2018-Aug-16 00:00     19 06 31.65 -12 24 57.8  13.01   6.78 1.12324700259848   7.9028232 142.4716 /T  17.7531
 2018-Aug-17 00:00     19 06 19.22 -12 31 04.7  13.03   6.79 1.12789294127252   8.1841452 141.5107 /T  18.1627
 2018-Aug-18 00:00     19 06 08.84 -12 37 11.5  13.05   6.80 1.13269963930351   8.4595089 140.5544 /T  18.5663
 2018-Aug-19 00:00     19 06 00.53 -12 43 17.9  13.07   6.81 1.13766368348632   8.7290131 139.6032 /T  18.9638
 2018-Aug-20 00:00     19 05 54.32 -12 49 23.7  13.09   6.82 1.14278172017487   8.9927641 138.6572 /T  19.3549
 2018-Aug-21 00:00     19 05 50.21 -12 55 28.5  13.11   6.83 1.14805045798011   9.2508711 137.7166 /T  19.7394
 2018-Aug-22 00:00     19 05 48.21 -13 01 32.1  13.13   6.84 1.15346666918303   9.5034453 136.7818 /T  20.1174
 2018-Aug-23 00:00     19 05 48.34 -13 07 34.2  13.15   6.85 1.15902719132090   9.7506017 135.8528 /T  20.4886
$$EOE
*******************************************************************************************************
Column meaning:

TIME

  Prior to 1962, times are UT1. Dates thereafter are UTC. Any 'b' symbol in
the 1st-column denotes a B.C. date. First-column blank (" ") denotes an A.D.
date. Calendar dates prior to 1582-Oct-15 are in the Julian calendar system.
Later calendar dates are in the Gregorian system.

  Time tags refer to the same instant throughout the solar system, regardless
of where the observer is located. For example, if an observation from the
surface of another body has an output time-tag of 12:31:00 UTC, an Earth-based
time-scale, it refers to the instant on that body simultaneous to 12:31:00 UTC
on Earth.

  The Barycentric Dynamical Time scale (TDB) is used internally as defined by
the planetary equations of motion. Conversion between TDB and the selected
non-uniform UT output time-scale has not been determined for UTC times after
the next July or January 1st. The last known leap-second is used as a constant
over future intervals.

  NOTE: "n.a." in output means quantity "not available" at the print-time.

 R.A._(ICRF/J2000.0)_DEC =
   Astrometric right ascension and declination of the TARGET CENTER with respec
to the observing site in the coordinates of the ICRF/J2000 inertial reference
frame. Compensated for down-leg light-time. Units: RA in hours-minutes-seconds
of time (HH MM SS.ff), DEC in angular degrees-minutes-seconds (DD MM SS.f)

 APmag S-brt =
   Asteroid's approximate apparent visual magnitude & surface brightness:
   APmag = H + 5*log10(delta) + 5*log10(r) - 2.5*log10((1-G)*phi1 + G*phi2)
For solar phase angles > 90 deg, the error could exceed 1 magnitude. For
phase angles > 120 degrees, output values are rounded to the nearest integer
to indicate the errors could be large and unknown.
   Units: NONE & VISUAL MAGNITUDES PER SQUARE ARCSECOND

 delta  deldot =
   Range ("delta") and range-rate ("delta-dot") of target center with respect
to the observer at the instant light seen by the observer at print-time would
have left the target center (print-time minus down-leg light-time); the
distance traveled by a light ray emanating from the center of the target and
recorded by the observer at print-time. "deldot" is a projection of the
velocity vector along this ray, the light-time-corrected line-of-sight from the
coordinate center, and indicates relative motion. A positive "deldot" means the
target center is moving away from the observer (coordinate center). A negative
"deldot" means the target center is moving toward the observer.
Units: AU and KM/S

 S-O-T /r =
    Sun-Observer-Target angle; target's apparent SOLAR ELONGATION seen from
the observer location at print-time. Angular units: DEGREES

    The '/r' column indicates the target's apparent position relative to
the Sun in the observer's sky, as described below:

    For an observing location on the surface of a rotating body
(considering its rotational sense):

    /T indicates target TRAILS Sun (evening sky; rises and sets AFTER Sun)
    /L indicates target LEADS Sun  (morning sky; rises and sets BEFORE Sun)

For an observing point NOT on a rotating body (such as a spacecraft), the
"leading" and "trailing" condition is defined by the observer's
heliocentric orbital motion: if continuing in the observer's current
direction of heliocentric motion would encounter the target's apparent
longitude first, followed by the Sun's, the target LEADS the Sun as seen by
the observer. If the Sun's apparent longitude would be encountered first,
followed by the target's, the target TRAILS the Sun.

NOTE: The S-O-T solar elongation angle is numerically the minimum
separation angle of the Sun and target in the sky in any direction. It
does NOT indicate the amount of separation in the leading or trailing
directions, which are defined in the equator of a spherical coordinate
system.

 S-T-O =
   "S-T-O" is the Sun->Target->Observer angle; the interior vertex angle at
target center formed by a vector to the apparent center of the Sun at
reflection time on the target and the apparent vector to the observer at
print-time. Slightly different from true PHASE ANGLE (requestable separately)
at the few arcsecond level in that it includes stellar aberration on the
down-leg from target to observer.  Units: DEGREES


 Computations by ...
     Solar System Dynamics Group, Horizons On-Line Ephemeris System
     4800 Oak Grove Drive, Jet Propulsion Laboratory
     Pasadena, CA  91109   USA
     Information: http://ssd.jpl.nasa.gov/
     Connect    : telnet://ssd.jpl.nasa.gov:6775  (via browser)
                  telnet ssd.jpl.nasa.gov 6775    (via command-line)
     Author     : Jon.D.Giorgini@jpl.nasa.gov

*******************************************************************************************************
```

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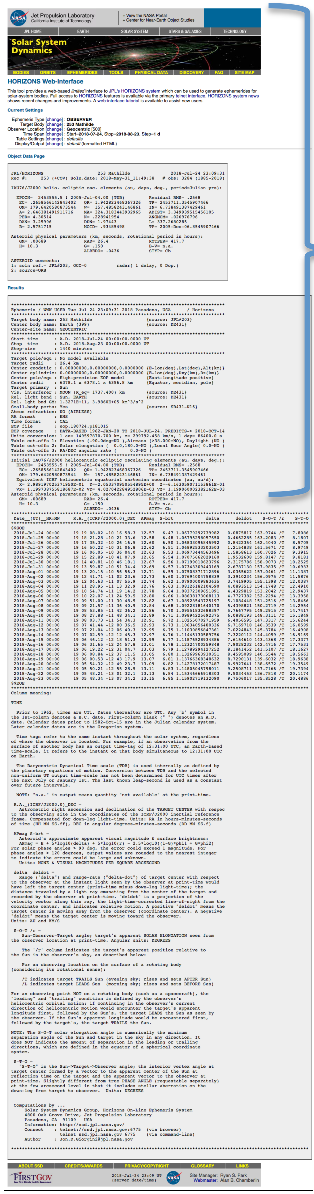
FIRSTGOV Your First Click to the U.S. Government

2018-Jul-24 23:09 UT
(server date/time)

Site Manager: Ryan S. Park
Webmaster: Alan B. Chamberlin



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Current Settings

Ephemeris Type [change] : **OBSERVER**
Target Body [change] : **253 Mathilde**
Observer Location [change] : **Geocentric** [500]
Time Span [change] : Start=**2018-07-24**, Stop=**2018-08-23**, Step=**1 d**
Table Settings [change] : *defaults*
Display/Output [change] : *default* (formatted HTML)

Object Data Page

```
JPL/HORIZONS                      253 Mathilde                 2018-Jul-24 23:09:31
Rec #:      253 (+COV) Soln.date: 2018-May-31_11:49:38   # obs: 3284 (1885-2018)

IAU76/J2000 helio. ecliptic osc. elements (au, days, deg., period=Julian yrs):

  EPOCH=  2453555.5 ! 2005-Jul-04.00 (TDB)         Residual RMS= .2568
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   B= 2.5751715             MOID= .93485498         TP= 2005-Dec-06.8545907466

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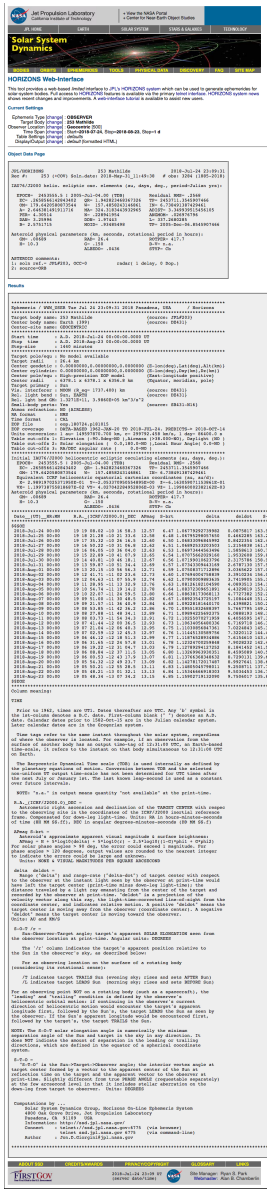
   H= 10.3                  G= .150                 B-V= n.a.
                            ALBEDO= .0436           STYP= Cb

ASTEROID comments:
1: soln ref.= JPL#203, OCC=0           radar( 1 delay, 0 Dop.)
2: source=ORB
```

Results

```
*******************************************************************************
Ephemeris / WWW_USER Tue Jul 24 23:09:31 2018 Pasadena, USA      / Horizons
*******************************************************************************
Target body name: 253 Mathilde                    {source: JPL#203}
Center body name: Earth (399)                     {source: DE431}
Center-site name: GEOCENTRIC
*******************************************************************************
Start time      : A.D. 2018-Jul-24 00:00:00.0000 UT
Stop  time      : A.D. 2018-Aug-23 00:00:00.0000 UT
Step-size       : 1440 minutes
*******************************************************************************
Target pole/equ : No model available
Target radii    : 26.4 km
Center geodetic : 0.00000000,0.00000000,0.0000000 {E-lon(deg),Lat(deg),Alt(km)}
Center cylindric: 0.00000000,0.00000000,0.0000000 {E-lon(deg),Dxy(km),Dz(km)}
Center pole/equ : High-precision EOP model        {East-longitude positive}
Center radii    : 6378.1 x 6378.1 x 6356.8 km     {Equator, meridian, pole}
Target primary  : Sun
Vis. interferer : MOON (R_eq= 1737.400) km        {source: DE431}
Rel. light bend : Sun, EARTH                      {source: DE431}
Rel. lght bnd GM: 1.3271E+11, 3.9860E+05 km^3/s^2
Small-body perts: Yes                             {source: SB431-N16}
Atmos refraction: NO (AIRLESS)
RA format       : HMS
Time format     : CAL
EOP file        : eop.180724.p181015
EOP coverage    : DATA-BASED 1962-JAN-20 TO 2018-JUL-24. PREDICTS-> 2018-OCT-14
Units conversion: 1 au= 149597870.700 km, c= 299792.458 km/s, 1 day= 86400.0 s
Table cut-offs 1: Elevation (-90.0deg=NO ),Airmass (>38.000=NO), Daylight (NO )
Table cut-offs 2: Solar elongation (  0.0,180.0=NO ),Local Hour Angle( 0.0=NO )
Table cut-offs 3: RA/DEC angular rate (     0.0=NO )
*******************************************************************************
Initial IAU76/J2000 heliocentric ecliptic osculating elements (au, days, deg.):
  EPOCH=  2453555.5 ! 2005-Jul-04.00 (TDB)         Residual RMS= .2568
   EC= .26585566142843402   QR= 1.942823468367326   TP= 2453711.3545907466
   OM= 179.6420580873544    W=  157.4858243146861   IN= 6.738491387429461
  Equivalent ICRF heliocentric equatorial cartesian coordinates (au, au/d):
   X= 2.989197025371950E-01  Y=-2.053370950554895E+00  Z=-6.163059071153861E-01
  VX= 1.199738755818687E-02 VY= 4.027042284952806E-03 VZ= 1.199060023382162E-03
Asteroid physical parameters (km, seconds, rotational period in hours):
   GM= .00689               RAD= 26.4               ROTPER= 417.7
   H= 10.3                  G= .150                 B-V= n.a.
```



Results

```
*******************************************************************************
Ephemeris / WWW_USER Tue Jul 24 23:09:31 2018 Pasadena, USA      / Horizons
*******************************************************************************
Target body name: 253 Mathilde                    {source: JPL#203}
Center body name: Earth (399)                     {source: DE431}
Center-site name: GEOCENTRIC
*******************************************************************************
Start time      : A.D. 2018-Jul-24 00:00:00.0000 UT
Stop  time      : A.D. 2018-Aug-23 00:00:00.0000 UT
Step-size       : 1440 minutes
*******************************************************************************
Target pole/equ : No model available
Target radii    : 26.4 km
Center geodetic : 0.00000000,0.00000000,0.0000000 {E-lon(deg),Lat(deg),Alt(km)}
Center cylindric: 0.00000000,0.00000000,0.0000000 {E-lon(deg),Dxy(km),Dz(km)}
Center pole/equ : High-precision EOP model        {East-longitude positive}
Center radii    : 6378.1 x 6378.1 x 6356.8 km     {Equator, meridian, pole}
Target primary  : Sun
Vis. interferer : MOON (R_eq= 1737.400) km        {source: DE431}
Rel. light bend : Sun, EARTH                      {source: DE431}
Rel. lght bnd GM: 1.3271E+11, 3.9860E+05 km^3/s^2
Small-body perts: Yes                             {source: SB431-N16}
Atmos refraction: NO (AIRLESS)
RA format       : HMS
Time format     : CAL
EOP file        : eop.180724.p181015
EOP coverage    : DATA-BASED 1962-JAN-20 TO 2018-JUL-24. PREDICTS-> 2018-OCT-14
Units conversion: 1 au= 149597870.700 km, c= 299792.458 km/s, 1 day= 86400.0 s
Table cut-offs 1: Elevation (-90.0deg=NO ),Airmass (>38.000=NO), Daylight (NO )
Table cut-offs 2: Solar elongation (  0.0,180.0=NO ),Local Hour Angle(  0.0=NO )
Table cut-offs 3: RA/DEC angular rate (     0.0=NO )
*******************************************************************************
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  EPOCH=  2453555.5 ! 2005-Jul-04.00 (TDB)         Residual RMS= .2568
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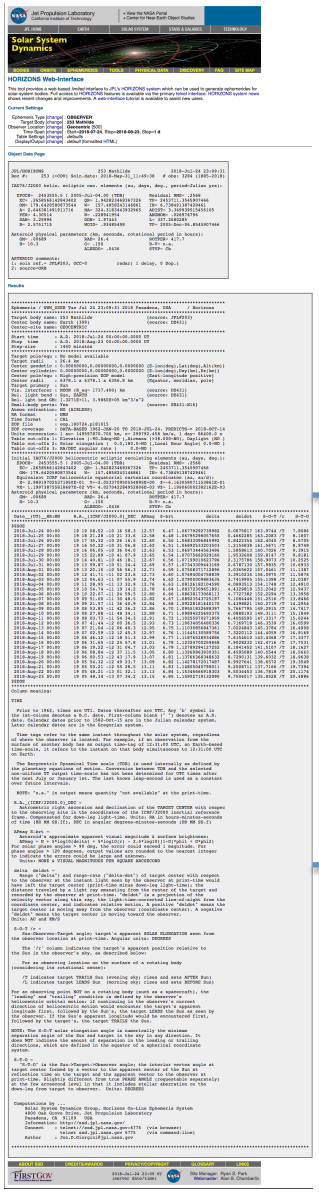
    GM= .00689                RAD= 26.4               ROTPER= 417.7
    H= 10.3                   G= .150                 B-V= n.a.
                              ALBEDO= .0436           STYP= Cb
*******************************************************************************
 Date__(UT)__HR:MN     R.A._(ICRF/J2000.0)_DEC  APmag  S-brt          delta      deldot     S-O-T /r     S-T-O
*******************************************************************************
$$SOE
 2018-Jul-24 00:00     19 19 08.02 -10 16 58.3  12.57    6.47 1.06779292739982   0.0875817 163.9744 /T    7.8086
 2018-Jul-25 00:00     19 18 21.28 -10 21 33.6  12.58    6.48 1.06795298057650   0.4662285 163.2083 /T    8.1807
 2018-Jul-26 00:00     19 17 35.32 -10 26 16.5  12.60    6.50 1.06833096845992   0.8422354 162.4040 /T    8.5705
 2018-Jul-27 00:00     19 16 50.22 -10 31 06.8  12.62    6.51 1.06892533203503   1.2154838 161.5671 /T    8.9749
 2018-Jul-28 00:00     19 16 06.05 -10 36 04.0  12.63    6.53 1.06973444563496   1.5858613 160.7026 /T    9.3915
 2018-Jul-29 00:00     19 15 22.89 -10 41 07.9  12.65    6.54 1.07075662029160   1.9532608 159.8147 /T    9.8181
 2018-Jul-30 00:00     19 14 40.81 -10 46 18.1  12.67    6.56 1.07199010623796   2.3175786 158.9073 /T   10.2525
 2018-Jul-31 00:00     19 13 59.87 -10 51 34.4  12.69    6.57 1.07343309443169   2.6787130 157.9835 /T   10.6933
 2018-Aug-01 00:00     19 13 20.15 -10 56 56.3  12.71    6.59 1.07508371712896   3.0365622 157.0461 /T   11.1387
 2018-Aug-02 00:00     19 12 41.71 -11 02 23.6  12.73    6.60 1.07694004758839   3.3910234 156.0975 /T   11.5876
 2018-Aug-03 00:00     19 12 04.63 -11 07 55.9  12.74    6.62 1.07900009883635   3.7419905 155.1398 /T   12.0387
 2018-Aug-04 00:00     19 11 28.95 -11 13 32.9  12.76    6.63 1.08126182104590   4.0893513 154.1748 /T   12.4910
 2018-Aug-05 00:00     19 10 54.74 -11 19 14.2  12.78    6.64 1.08372309651891   4.4329819 153.2042 /T   12.9437
 2018-Aug-06 00:00     19 10 22.07 -11 24 59.5  12.80    6.66 1.08638173068113   4.7727382 152.2294 /T   13.3958
 2018-Aug-07 00:00     19 09 51.00 -11 30 48.5  12.82    6.67 1.08923543725197   5.1084448 151.2516 /T   13.8466
 2018-Aug-08 00:00     19 09 21.57 -11 36 40.9  12.84    6.68 1.09228181640170   5.4398821 150.2719 /T   14.2954
 2018-Aug-09 00:00     19 08 53.85 -11 42 36.2  12.86    6.70 1.09551832688397   5.7667795 149.2915 /T   14.7417
 2018-Aug-10 00:00     19 08 27.88 -11 48 34.1  12.89    6.71 1.09894225692375   6.0888193 148.3111 /T   15.1849
```

Coordinates



```
  X= 2.989197025371950E-01  Y=-2.053370950554895E+00  Z=-6.163059071153861E-01
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*******************************************************************************************************
 Date__(UT)__HR:MN     R.A._(ICRF/J2000.0)_DEC  APmag  S-brt             delta      deldot     S-O-T /r    S-T-O
*******************************************************************************************************
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 2018-Jul-24 00:00     19 19 08.02 -10 16 58.3   12.57    6.47 1.06779292739982   0.0875817 163.9744 /T    7.8086
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 2018-Jul-27 00:00     19 16 50.22 -10 31 06.8   12.62    6.51 1.06892533203503   1.2154838 161.5671 /T    8.9749
 2018-Jul-28 00:00     19 16 06.05 -10 36 04.0   12.63    6.53 1.06973444563496   1.5858613 160.7026 /T    9.3915
 2018-Jul-29 00:00     19 15 22.89 -10 41 07.9   12.65    6.54 1.07075662029160   1.9532608 159.8147 /T    9.8181
 2018-Jul-30 00:00     19 14 40.81 -10 46 18.1   12.67    6.56 1.07199010623796   2.3175786 158.9073 /T   10.2525
 2018-Jul-31 00:00     19 13 59.87 -10 51 34.4   12.69    6.57 1.07343309443169   2.6787130 157.9835 /T   10.6933
 2018-Aug-01 00:00     19 13 20.15 -10 56 56.3   12.71    6.59 1.07508371712896   3.0365622 157.0461 /T   11.1387
 2018-Aug-02 00:00     19 12 41.71 -11 02 23.6   12.73    6.60 1.07694004758839   3.3910234 156.0975 /T   11.5876
 2018-Aug-03 00:00     19 12 04.63 -11 07 55.9   12.74    6.62 1.07900009883635   3.7419905 155.1398 /T   12.0387
 2018-Aug-04 00:00     19 11 28.95 -11 13 32.9   12.76    6.63 1.08126182104590   4.0893513 154.1748 /T   12.4910
 2018-Aug-05 00:00     19 10 54.74 -11 19 14.2   12.78    6.64 1.08372309651891   4.4329819 153.2042 /T   12.9437
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 2018-Aug-07 00:00     19 09 51.00 -11 30 48.5   12.82    6.67 1.08923543725197   5.1084448 151.2516 /T   13.8466
 2018-Aug-08 00:00     19 09 21.57 -11 36 40.9   12.84    6.68 1.09228181640170   5.4398821 150.2719 /T   14.2954
 2018-Aug-09 00:00     19 08 53.85 -11 42 36.2   12.86    6.70 1.09551832688397   5.7667795 149.2915 /T   14.7417
 2018-Aug-10 00:00     19 08 27.88 -11 48 34.1   12.89    6.71 1.09894225692375   6.0888193 148.3111 /T   15.1849
 2018-Aug-11 00:00     19 08 03.73 -11 54 34.3   12.91    6.72 1.10255070271959   6.4056595 147.3317 /T   15.6244
 2018-Aug-12 00:00     19 07 41.44 -12 00 36.5   12.93    6.73 1.10634056480336   6.7169718 146.3539 /T   16.0599
 2018-Aug-13 00:00     19 07 21.04 -12 06 40.3   12.95    6.75 1.11030856847361   7.0224843 145.3784 /T   16.4908
 2018-Aug-14 00:00     19 07 02.59 -12 12 45.3   12.97    6.76 1.11445130589756   7.3220112 144.4059 /T   16.9169
 2018-Aug-15 00:00     19 06 46.12 -12 18 51.3   12.99    6.77 1.11876528934886   7.6154610 143.4368 /T   17.3377
 2018-Aug-16 00:00     19 06 31.65 -12 24 57.8   13.01    6.78 1.12324700259848   7.9028232 142.4716 /T   17.7531
 2018-Aug-17 00:00     19 06 19.22 -12 31 04.7   13.03    6.79 1.12789294127252   8.1841452 141.5107 /T   18.1627
 2018-Aug-18 00:00     19 06 08.84 -12 37 11.5   13.05    6.80 1.13269963930351   8.4595089 140.5544 /T   18.5663
 2018-Aug-19 00:00     19 06 00.53 -12 43 17.9   13.07    6.81 1.13766368348632   8.7290131 139.6032 /T   18.9638
 2018-Aug-20 00:00     19 05 54.32 -12 49 23.7   13.09    6.82 1.14278172017487   8.9927641 138.6572 /T   19.3549
 2018-Aug-21 00:00     19 05 50.21 -12 55 28.5   13.11    6.83 1.14805045798011   9.2508711 137.7166 /T   19.7394
 2018-Aug-22 00:00     19 05 48.21 -13 01 32.1   13.13    6.84 1.15346666918303   9.5034453 136.7818 /T   20.1174
 2018-Aug-23 00:00     19 05 48.34 -13 07 34.2   13.15    6.85 1.15902719132090   9.7506017 135.8528 /T   20.4886
$$EOE
*******************************************************************************************************
Column meaning:

TIME

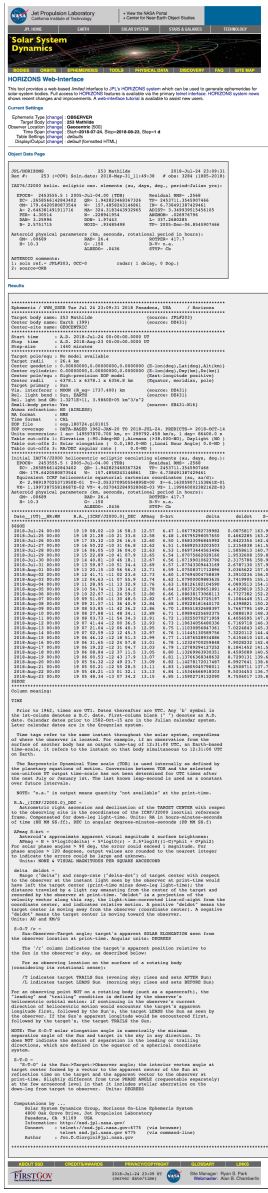
  Prior to 1962, times are UT1. Dates thereafter are UTC. Any 'b' symbol in
the 1st-column denotes a B.C. date. First-column blank (" ") denotes an A.D.
date. Calendar dates prior to 1582-Oct-15 are in the Julian calendar system.
Later calendar dates are in the Gregorian system.

  Time tags refer to the same instant throughout the solar system, regardless
of where the observer is located. For example, if an observation from the
surface of another body has an output time-tag of 12:31:00 UTC, an Earth-based
time-scale, it refers to the instant on that body simultaneous to 12:31:00 UTC
on Earth.

  The Barycentric Dynamical Time scale (TDB) is used internally as defined by
the planetary equations of motion. Conversion between TDB and the selected
non-uniform UT output time-scale has not been determined for UTC times after
the next July or January 1st. The last known leap-second is used as a constant
over future intervals.

  NOTE: "n.a." in output means quantity "not available" at the print-time.

 R.A._(ICRF/J2000.0)_DEC =
   Astrometric right ascension and declination of the TARGET CENTER with respec
to the observing site in the coordinates of the ICRF/J2000 inertial reference
frame. Compensated for down-leg light-time. Units: RA in hours-minutes-seconds
of time (HH MM SS.ff), DEC in angular degrees-minutes-seconds (DD MM SS.f)
```



to indicate the errors could be large and unknown.
   Units: NONE & VISUAL MAGNITUDES PER SQUARE ARCSECOND

 delta deldot =
   Range ("delta") and range-rate ("delta-dot") of target center with respect
to the observer at the instant light seen by the observer at print-time would
have left the target center (print-time minus down-leg light-time); the
distance traveled by a light ray emanating from the center of the target and
recorded by the observer at print-time. "deldot" is a projection of the
velocity vector along this ray, the light-time-corrected line-of-sight from the
coordinate center, and indicates relative motion. A positive "deldot" means the
target center is moving away from the observer (coordinate center). A negative
"deldot" means the target center is moving toward the observer.
Units: AU and KM/S

 S-O-T /r =
    Sun-Observer-Target angle; target's apparent SOLAR ELONGATION seen from
the observer location at print-time. Angular units: DEGREES

    The '/r' column indicates the target's apparent position relative to
the Sun in the observer's sky, as described below:

    For an observing location on the surface of a rotating body
(considering its rotational sense):

    /T indicates target TRAILS Sun (evening sky; rises and sets AFTER Sun)
    /L indicates target LEADS Sun (morning sky; rises and sets BEFORE Sun)

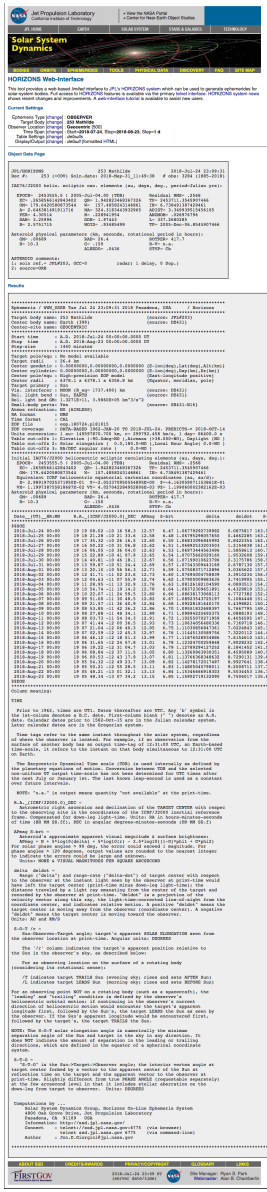
For an observing point NOT on a rotating body (such as a spacecraft), the
"leading" and "trailing" condition is defined by the observer's
heliocentric orbital motion: if continuing in the observer's current
direction of heliocentric motion would encounter the target's apparent
longitude first, followed by the Sun's, the target LEADS the Sun as seen by
the observer. If the Sun's apparent longitude would be encountered first,
followed by the target's, the target TRAILS the Sun.

NOTE: The S-O-T solar elongation angle is numerically the minimum
separation angle of the Sun and target in the sky in any direction. It
does NOT indicate the amount of separation in the leading or trailing
directions, which are defined in the equator of a spherical coordinate
system.

 S-T-O =
   "S-T-O" is the Sun->Target->Observer angle; the interior vertex angle at
target center formed by a vector to the apparent center of the Sun at
reflection time on the target and the apparent vector to the observer at
print-time. Slightly different from true PHASE ANGLE (requestable separately)
at the few arcsecond level in that it includes stellar aberration on the
down-leg from target to observer. Units: DEGREES

 Computations by ...
     Solar System Dynamics Group, Horizons On-Line Ephemeris System
     4800 Oak Grove Drive, Jet Propulsion Laboratory
     Pasadena, CA 91109   USA
     Information: http://ssd.jpl.nasa.gov/
     Connect   : telnet://ssd.jpl.nasa.gov:6775 (via browser)
                  telnet ssd.jpl.nasa.gov 6775   (via command-line)
     Author   : Jon.D.Giorgini@jpl.nasa.gov

****



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     Information: http://ssd.jpl.nasa.gov/
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                  telnet ssd.jpl.nasa.gov 6775    (via command-line)
     Author     : Jon.D.Giorgini@jpl.nasa.gov

*******************************************************************************************************************
```