`Oumuamua, the first known interstellar visitor

ESO

Davide Farnocchia

Jet Propulsion Laboratory
California Institute of Technology

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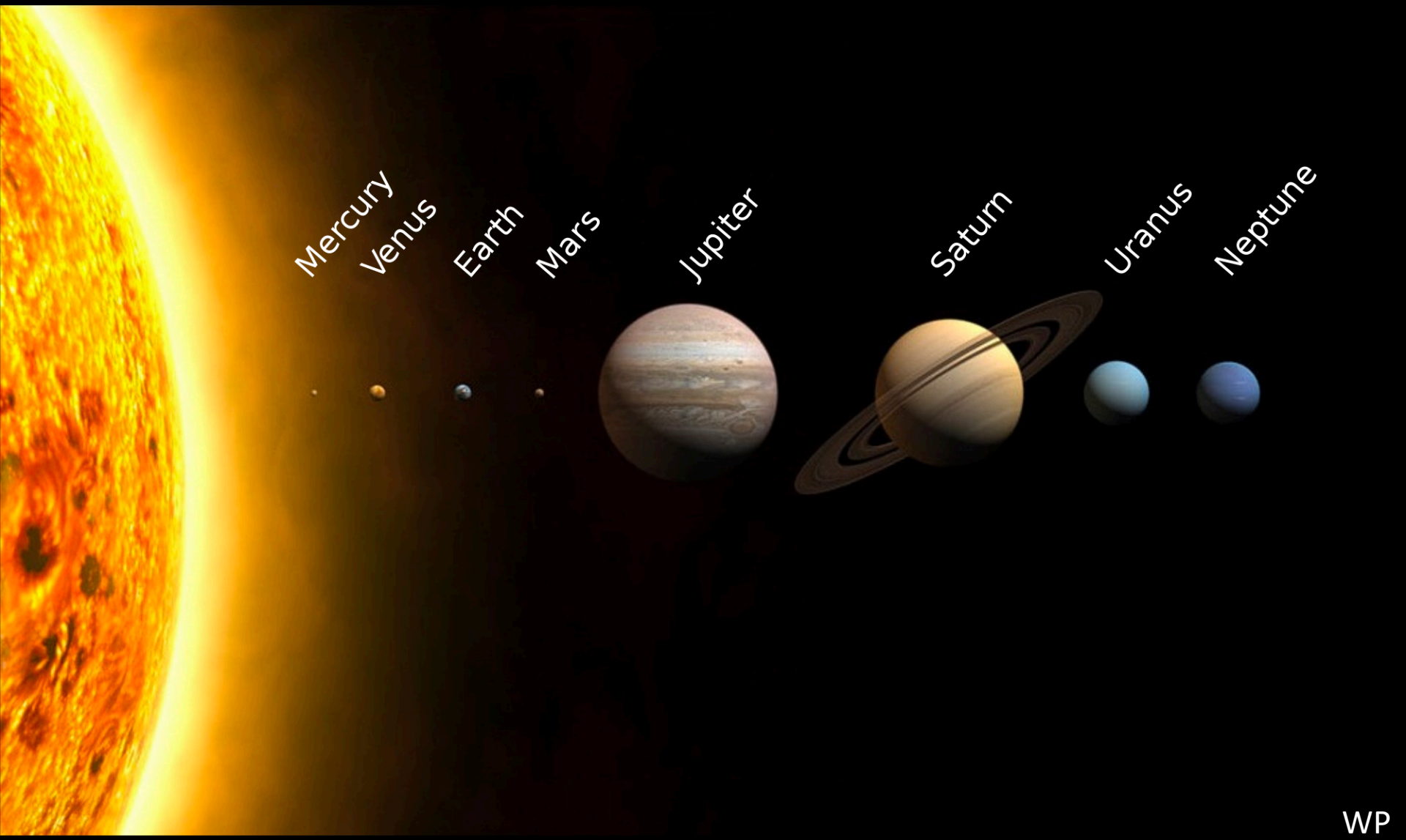
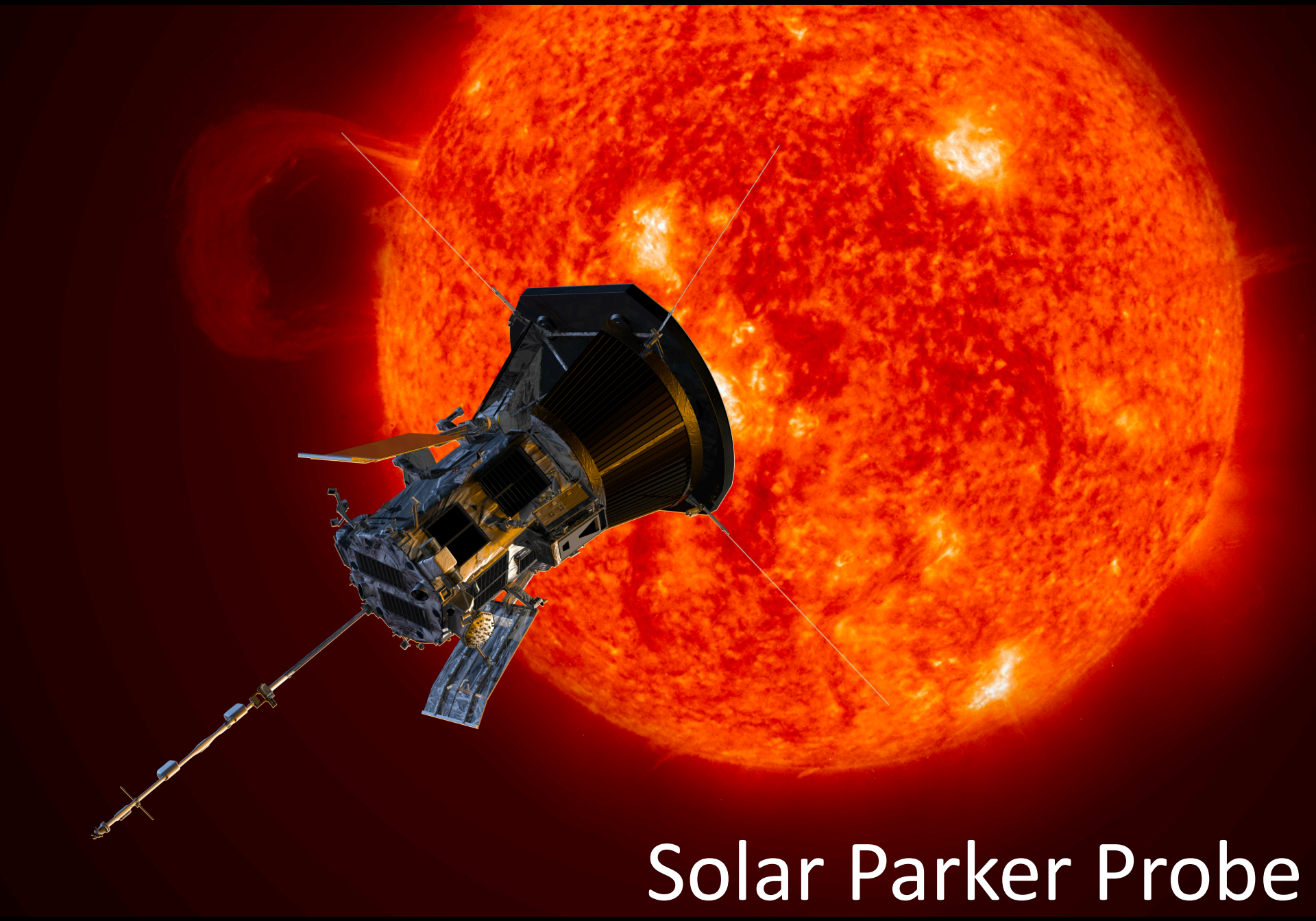
Where I am from

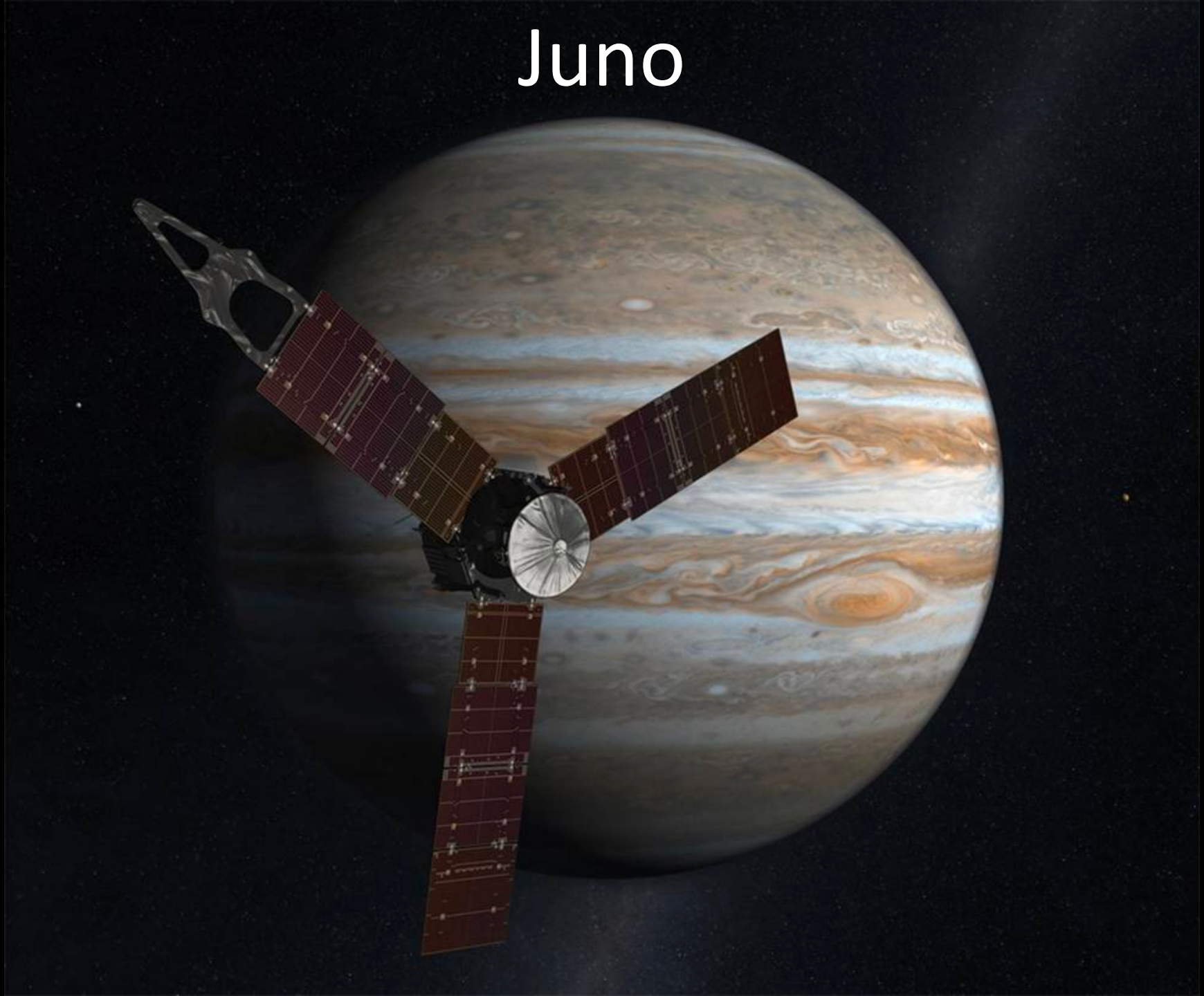
JPL's Solar System Dynamics Group



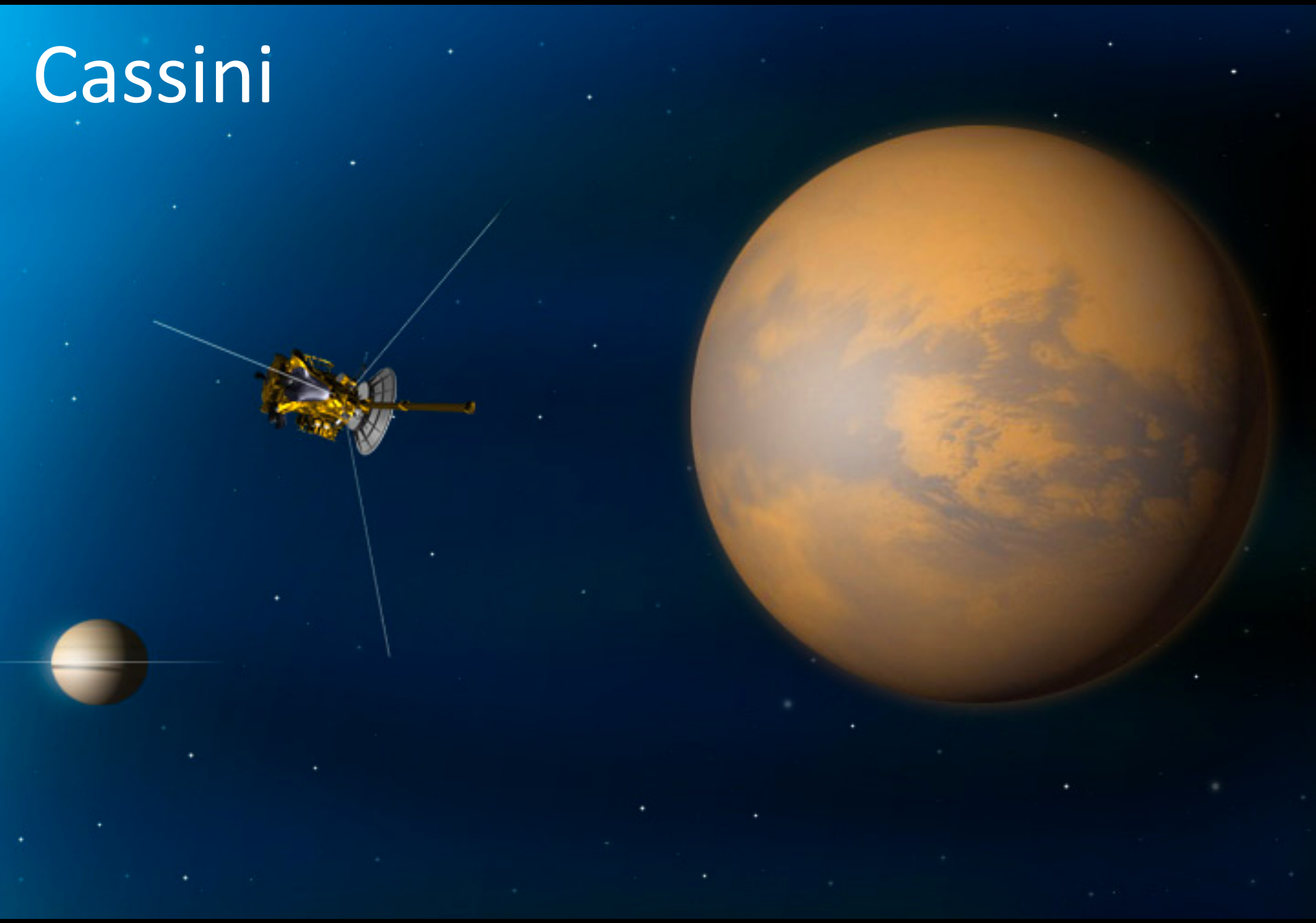
WP

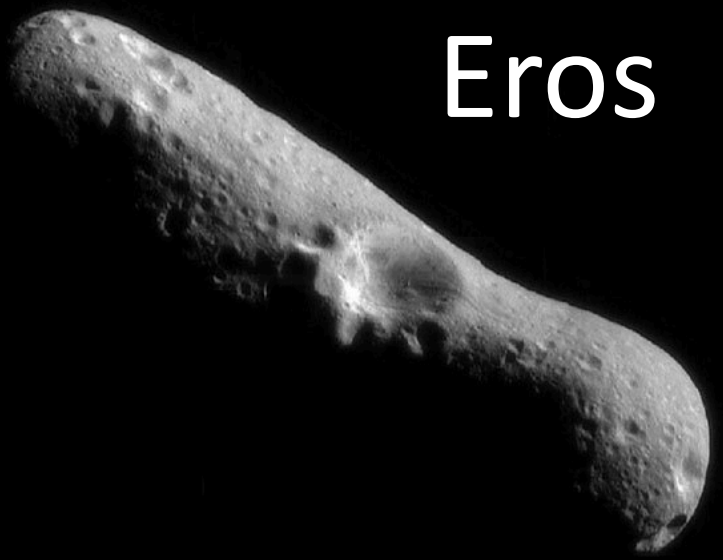

Solar Parker Probe

Juno

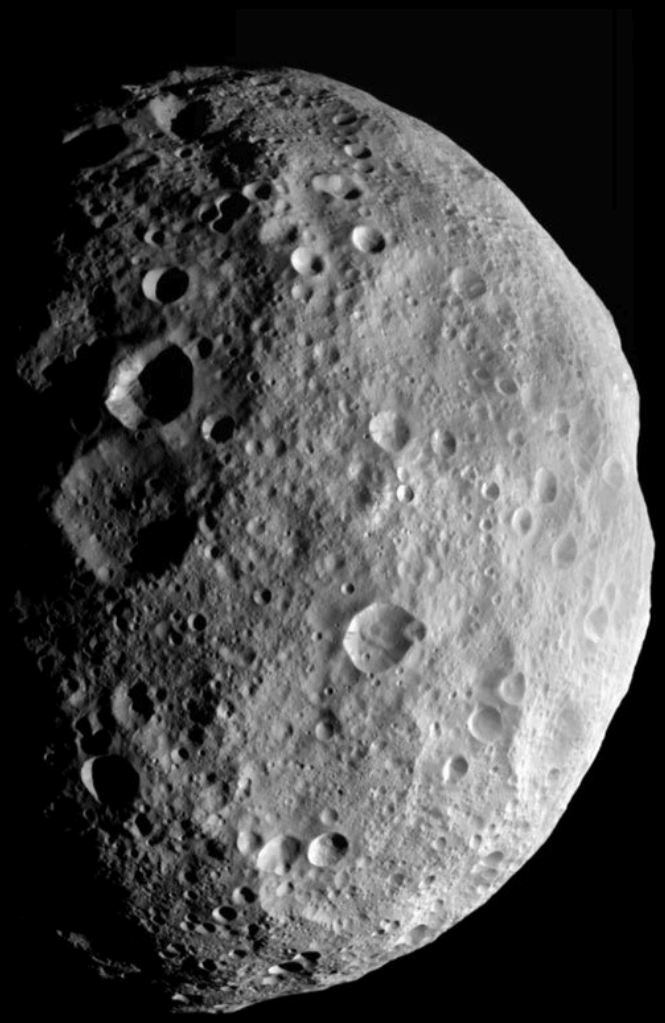


Cassini





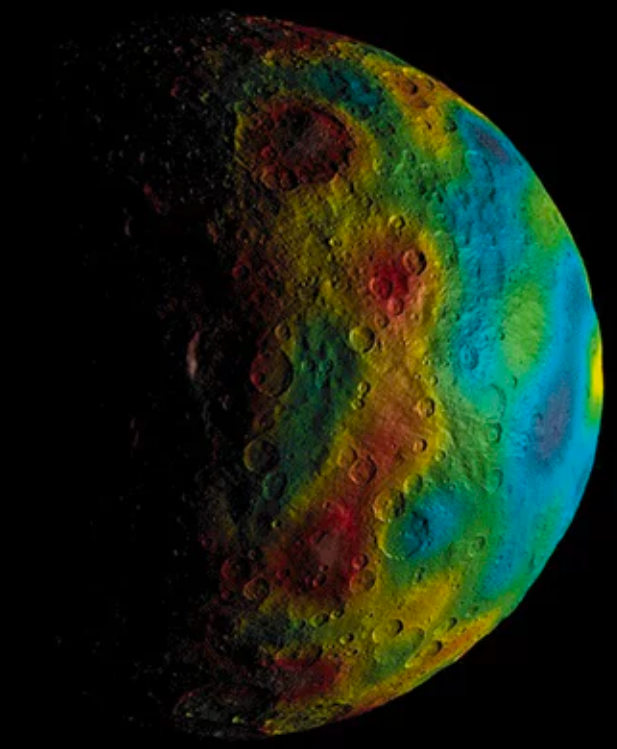
Eros



Vesta

Ceres

Shape



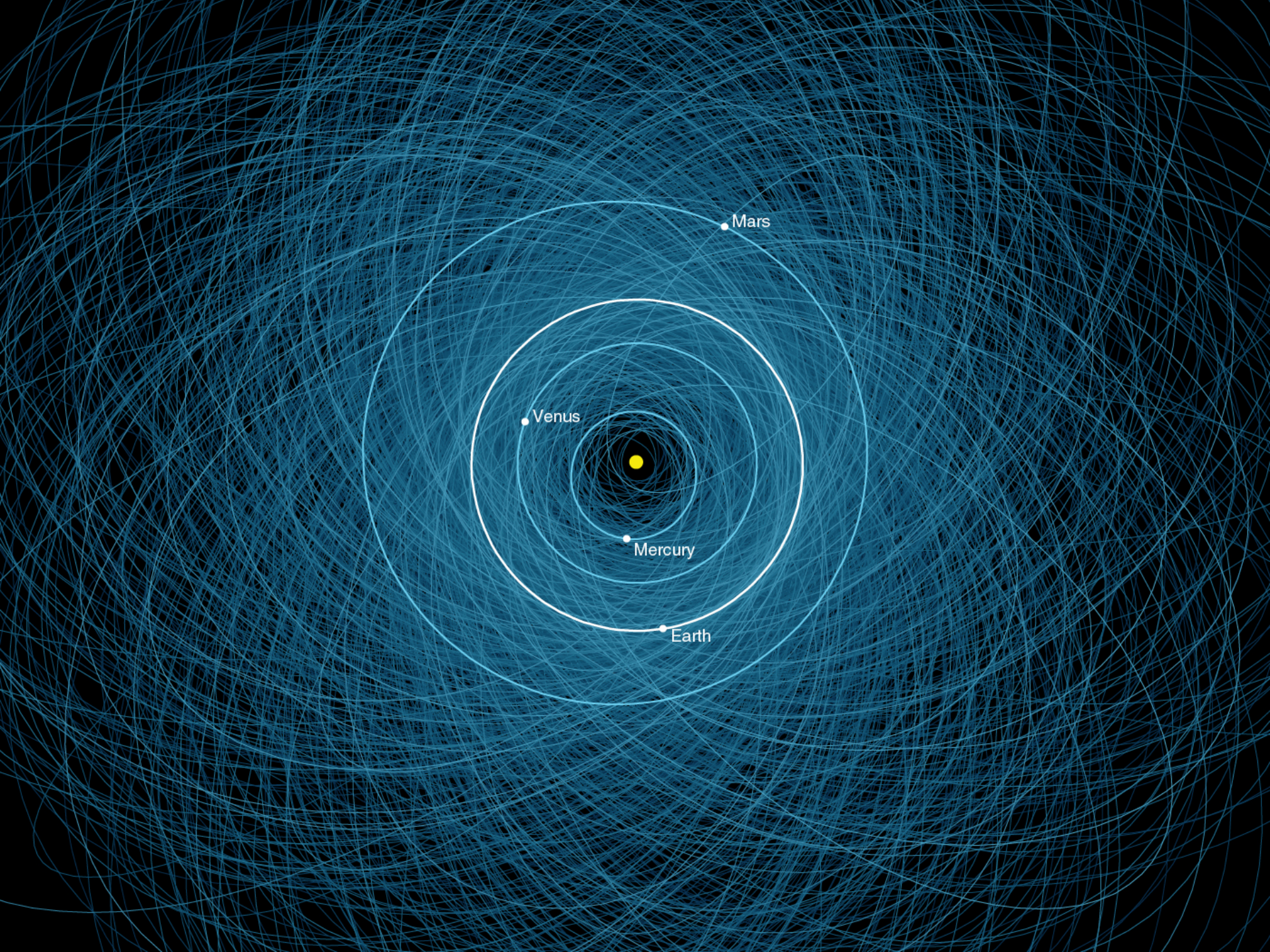
Gravity

Itokawa

ISAS / JAXA / Øyvind Guldbrandsen

OSIRIS-REx

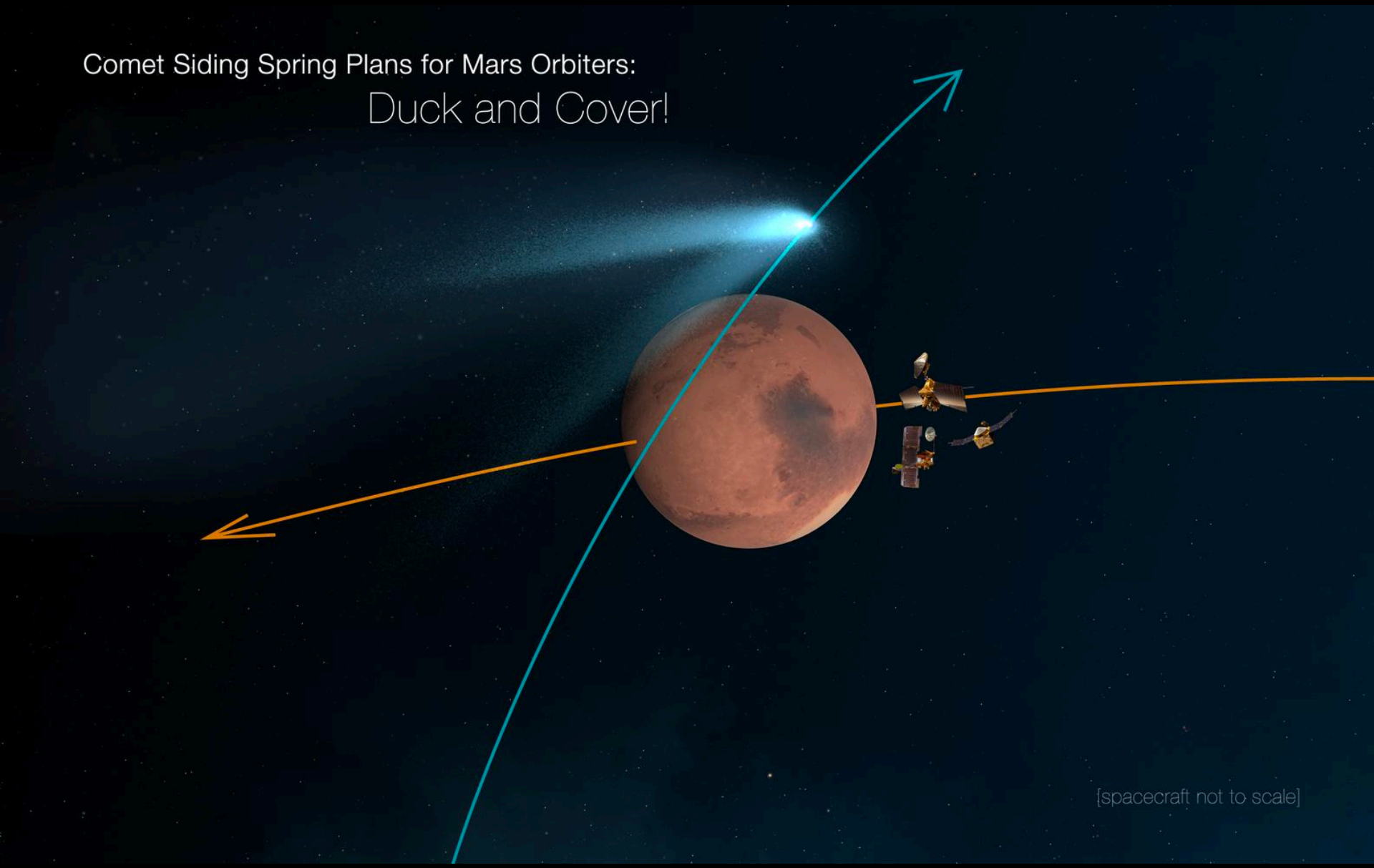
The animation represents a map of the increased count of all known asteroids in the solar system between Jan. 1, 1999 and Jan. 31, 2018. (Blue represents near-Earth asteroids. Orange represents main-belt asteroids between the orbits of Mars and Jupiter.)


Mars
Venus
Mercury
Earth

2017-Nov-09 04:05:43 UTC
1,000,000x time
Neptune
Earth
Sun
Mercury
Venus

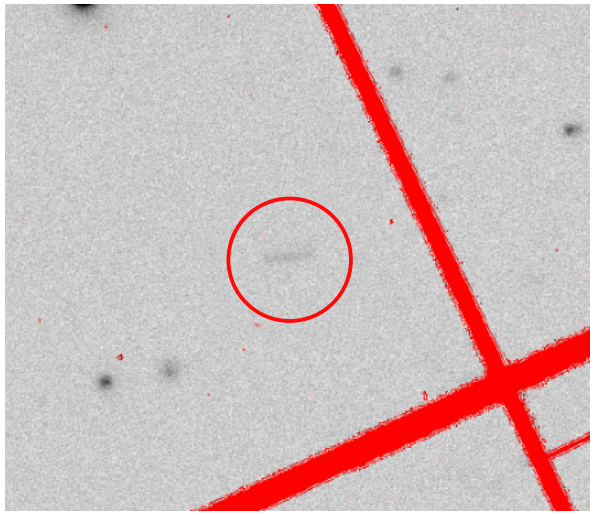
2018 LA

Democratic Republic of the Congo
Brazzaville
Kinshasa
Rwanda
Lake Victoria
Bujumbura
Nairobi
Tanzania
Lake Tanganyika
Dodoma
Luanda
Lake Rukwa
Angola
Lake Malawi
Malawi
Comoros
Moroni
Lilongwe
Zambia
Lusaka
Mamo
St Helena
Jamestown
Harare
Okavango Delta
Zimbabwe
Mozambique
Mozambique Channel
Namibia
Windhoek
Botswana
Madagascar
Kalahari Desert
Gaborone
Pretoria
Maputo
Mbabane
Swaziland
Drakensberg Mountains
Maseru
Lesotho
South Africa
© 2018 AfriGIS (Pty) Ltd.
US Dept of State Geographer
Image Landsat / Copernicus
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Google Earth

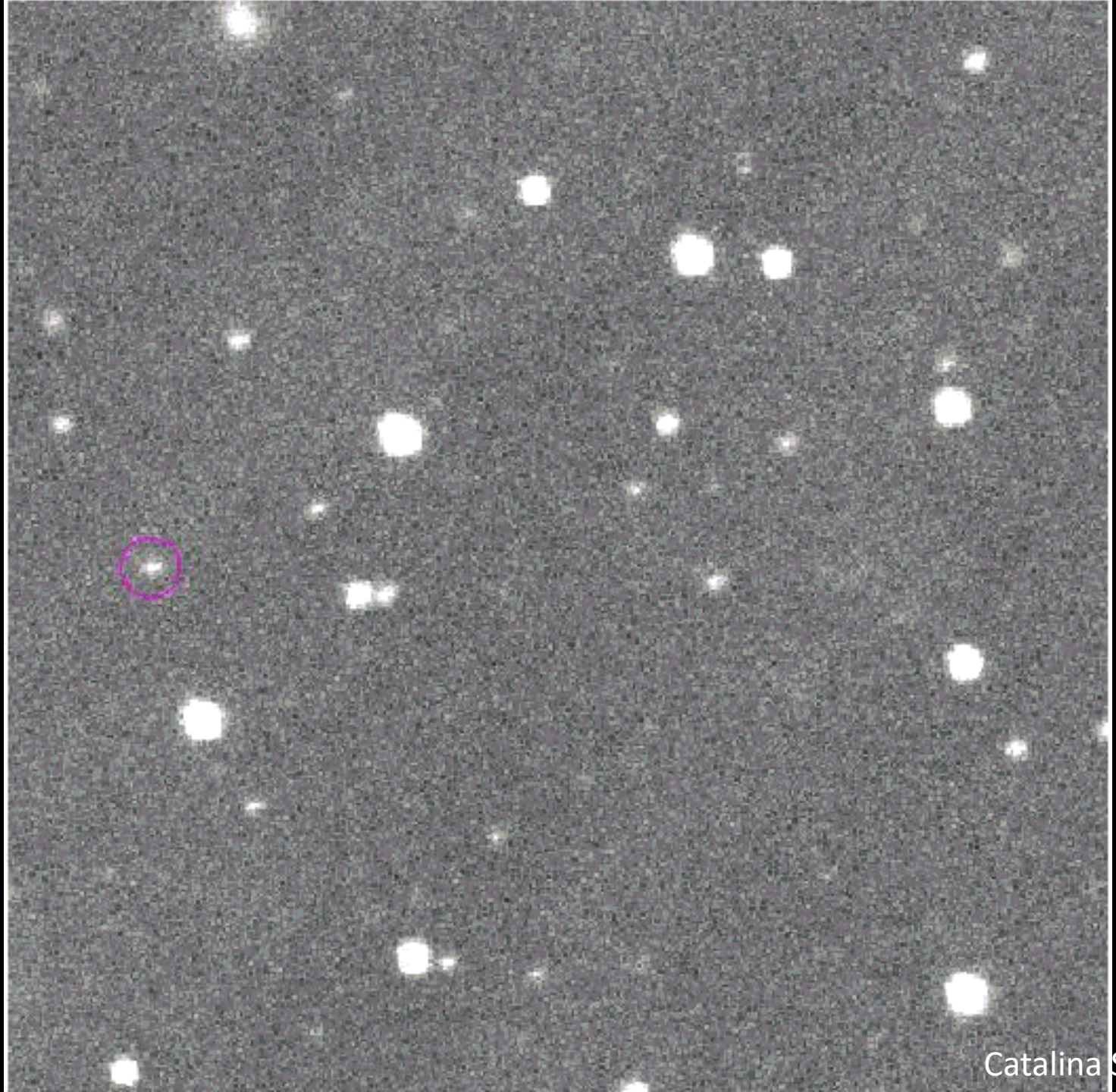

Comet Siding Spring Plans for Mars Orbiters:
Duck and Cover!
[spacecraft not to scale]

Discovery of `Oumuamua
Oct. 19, 2017

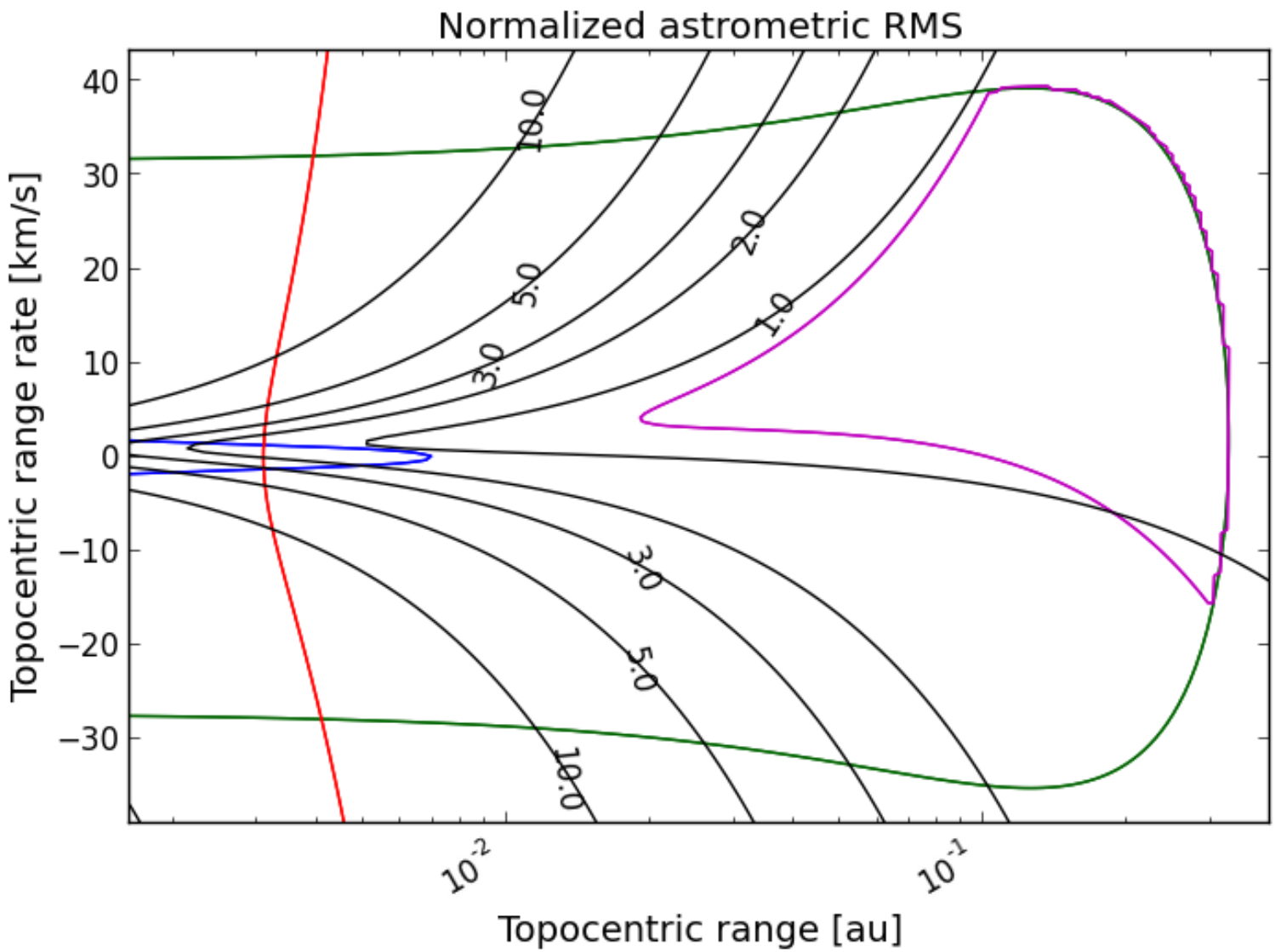
Pan-STARRS 1



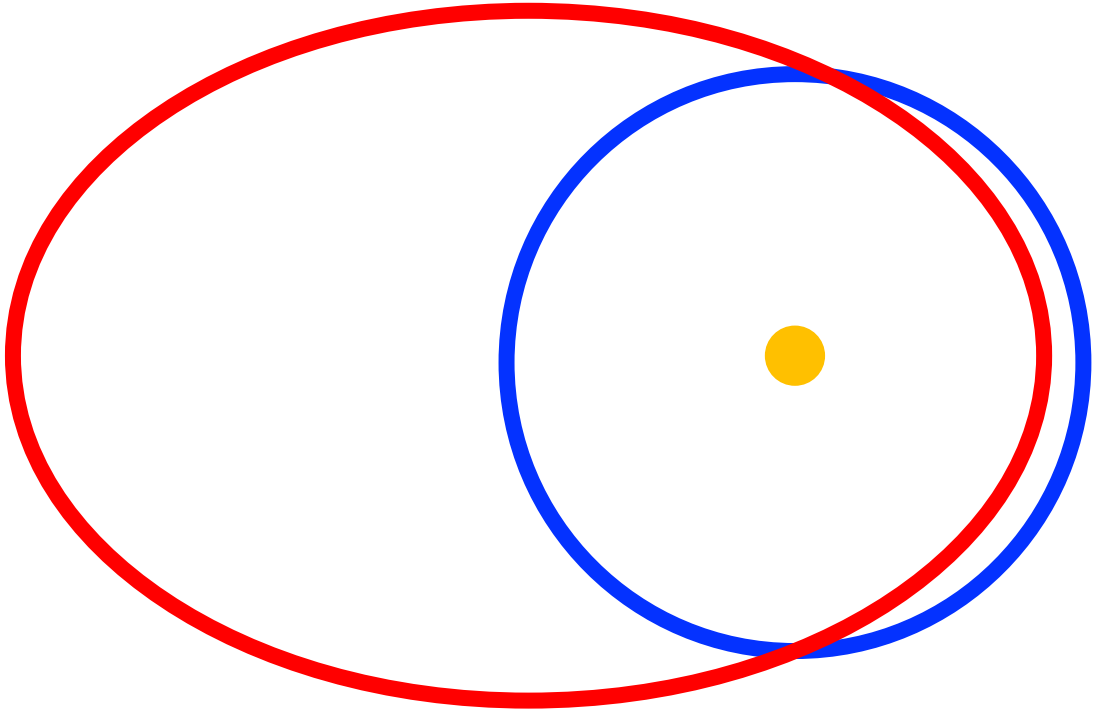
Meech et al. 2017


Catalina Sky Survey

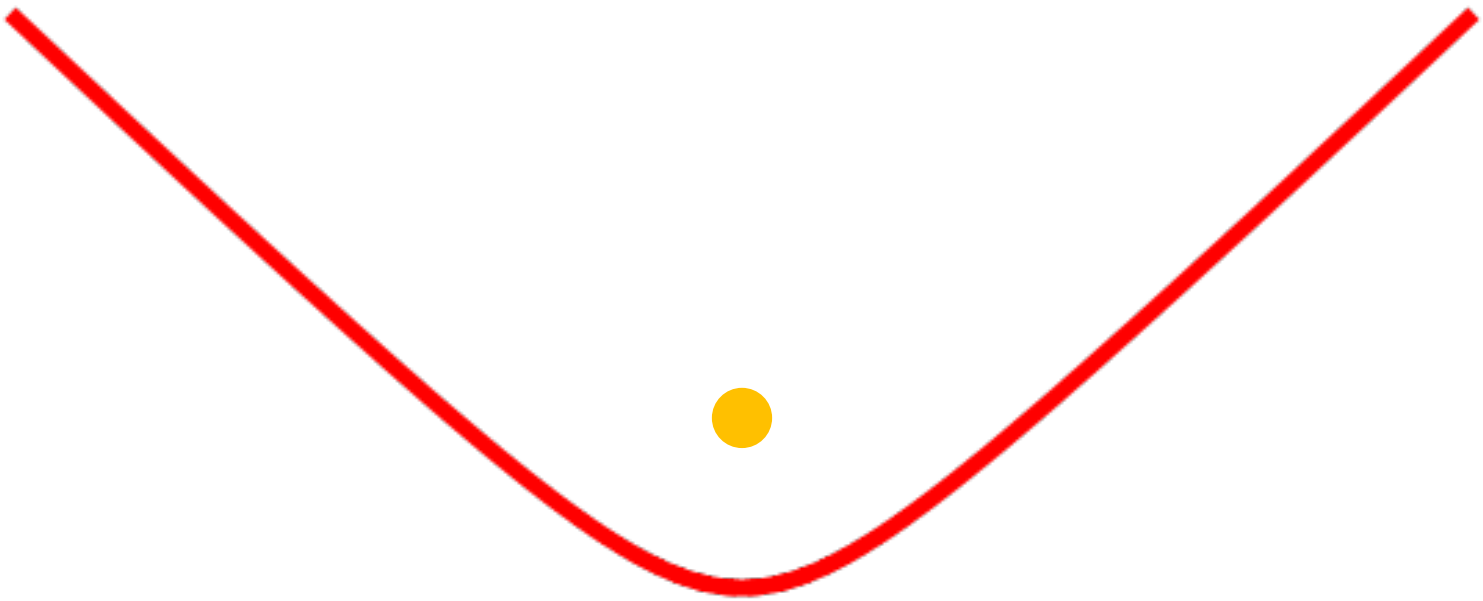
Initial orbit determination



Elliptical orbit

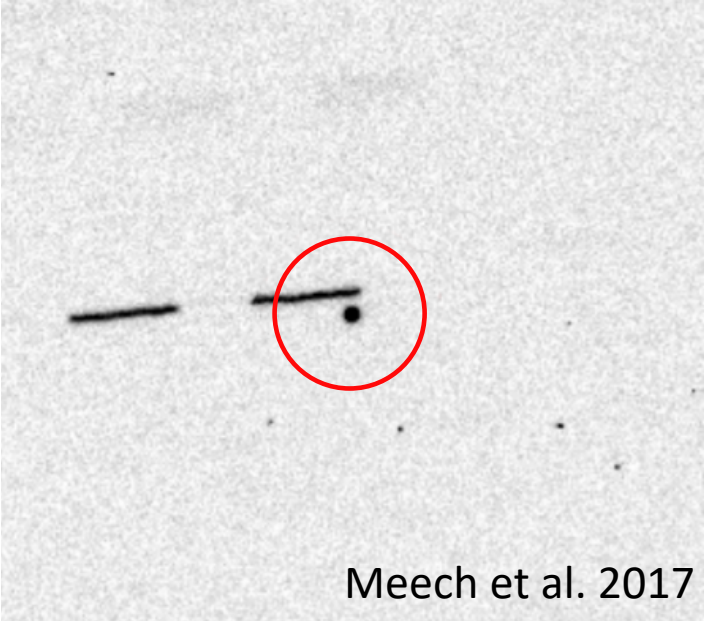


Hyperbolic orbit

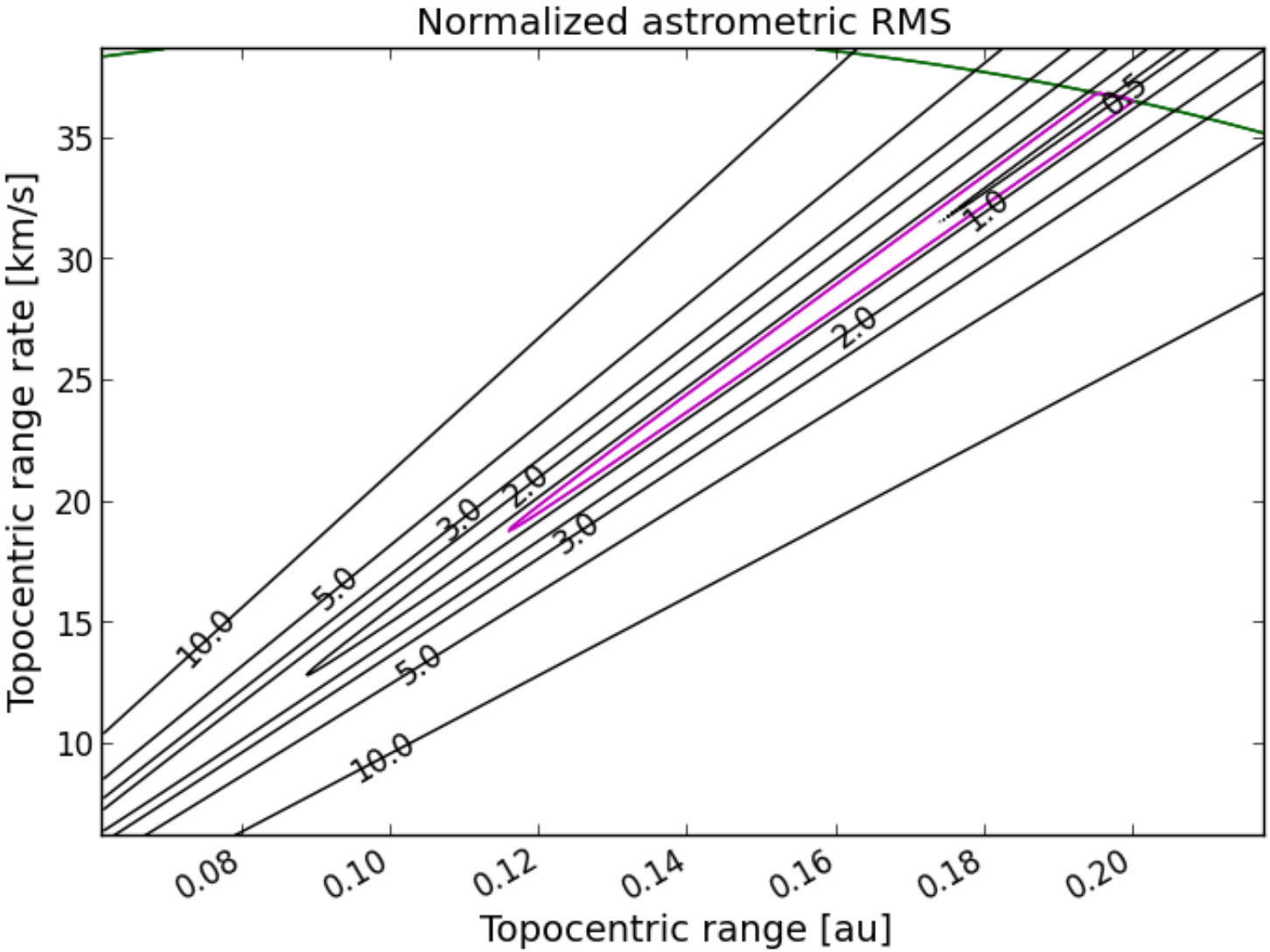


ESA OGS (1m)

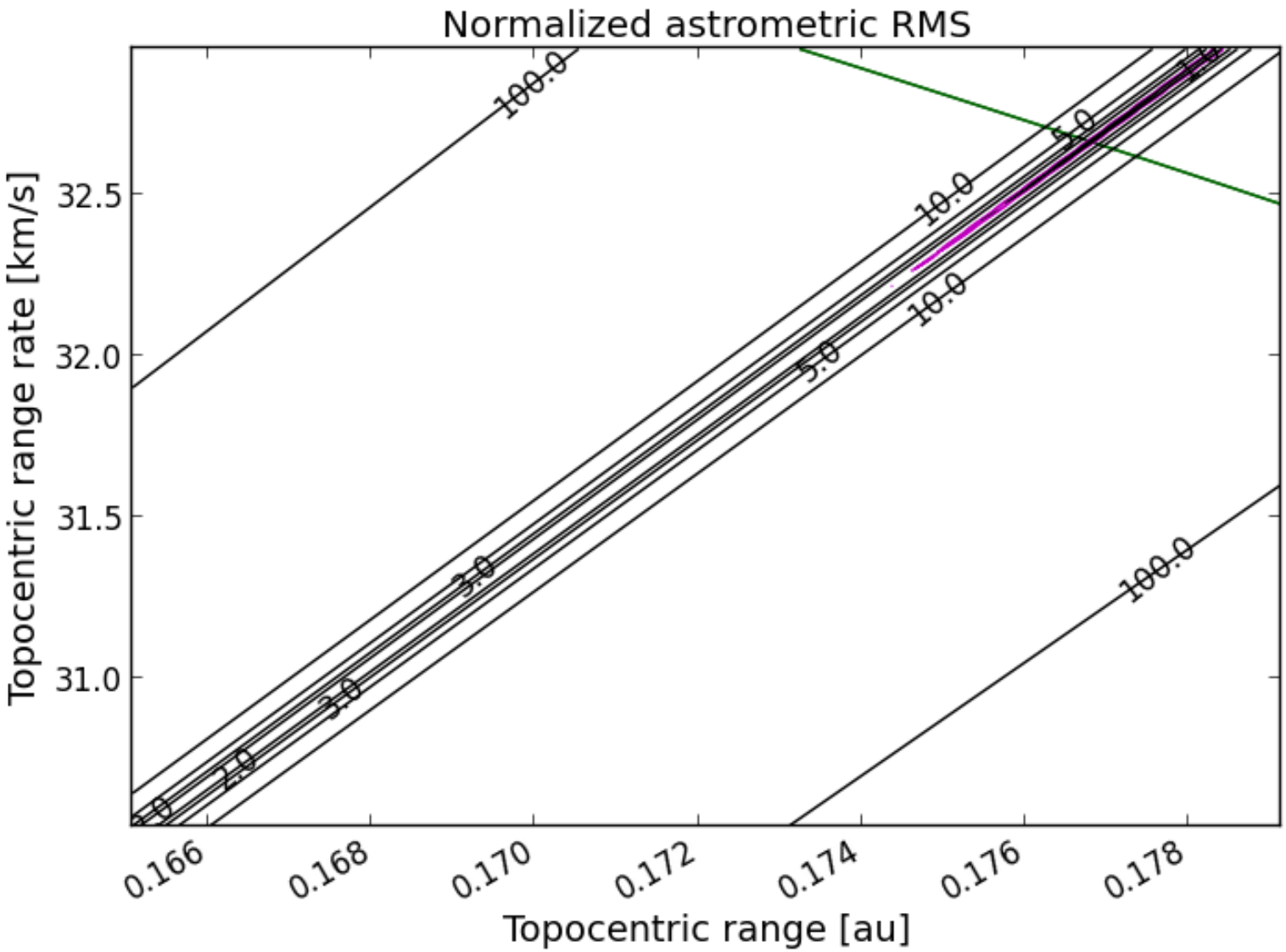
CFHT



Updated orbit determination



Updated orbit determination



M.P.E.C. 2017-U181 Issued 2017 Oct. 25, 03:53 UT

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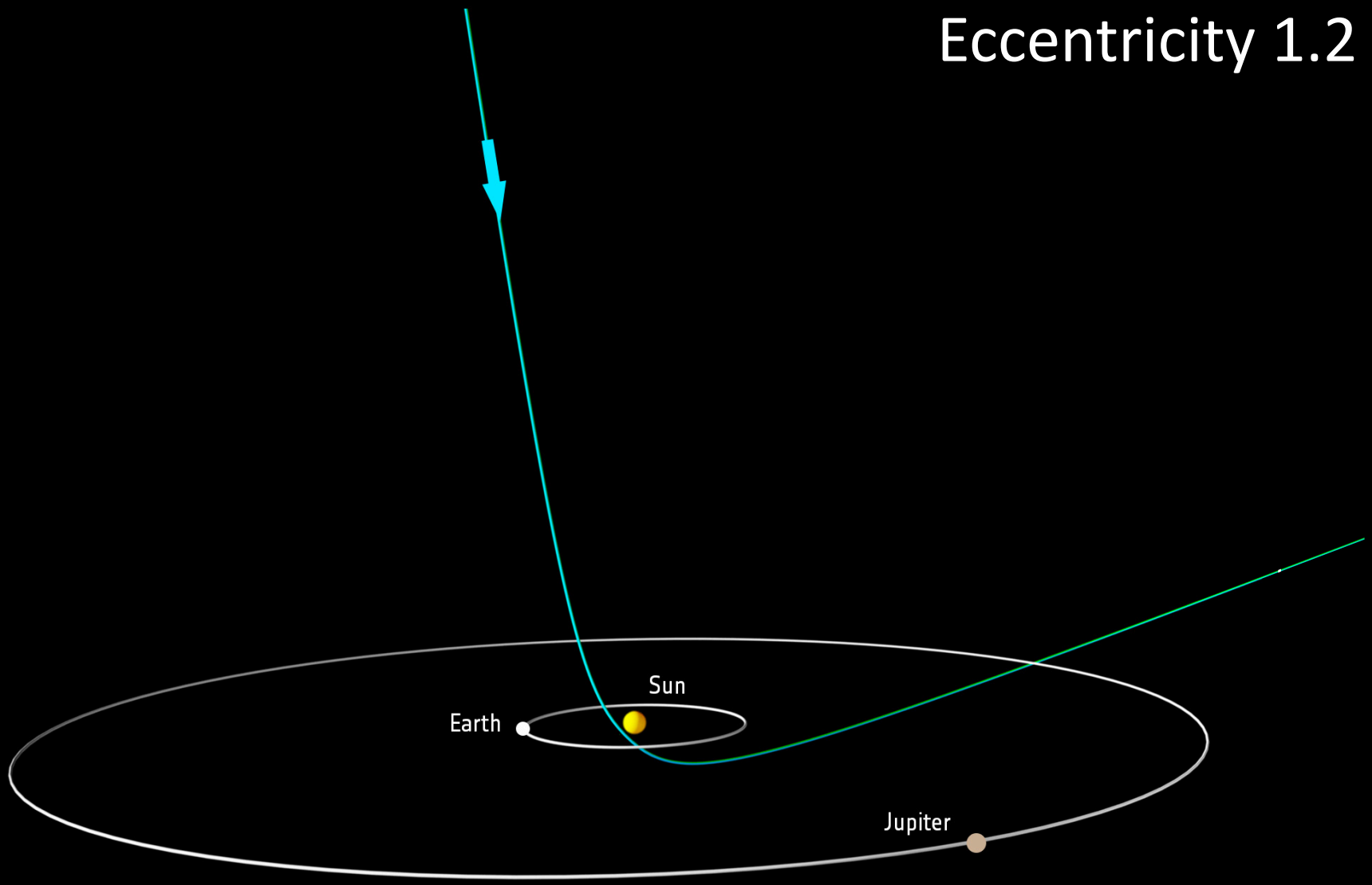
Prepared using the Tamkin Foundation Computer Network

MPC@CFA.HARVARD.EDU
URL https://www.minorplanetcenter.net/ ISSN 1523-6714

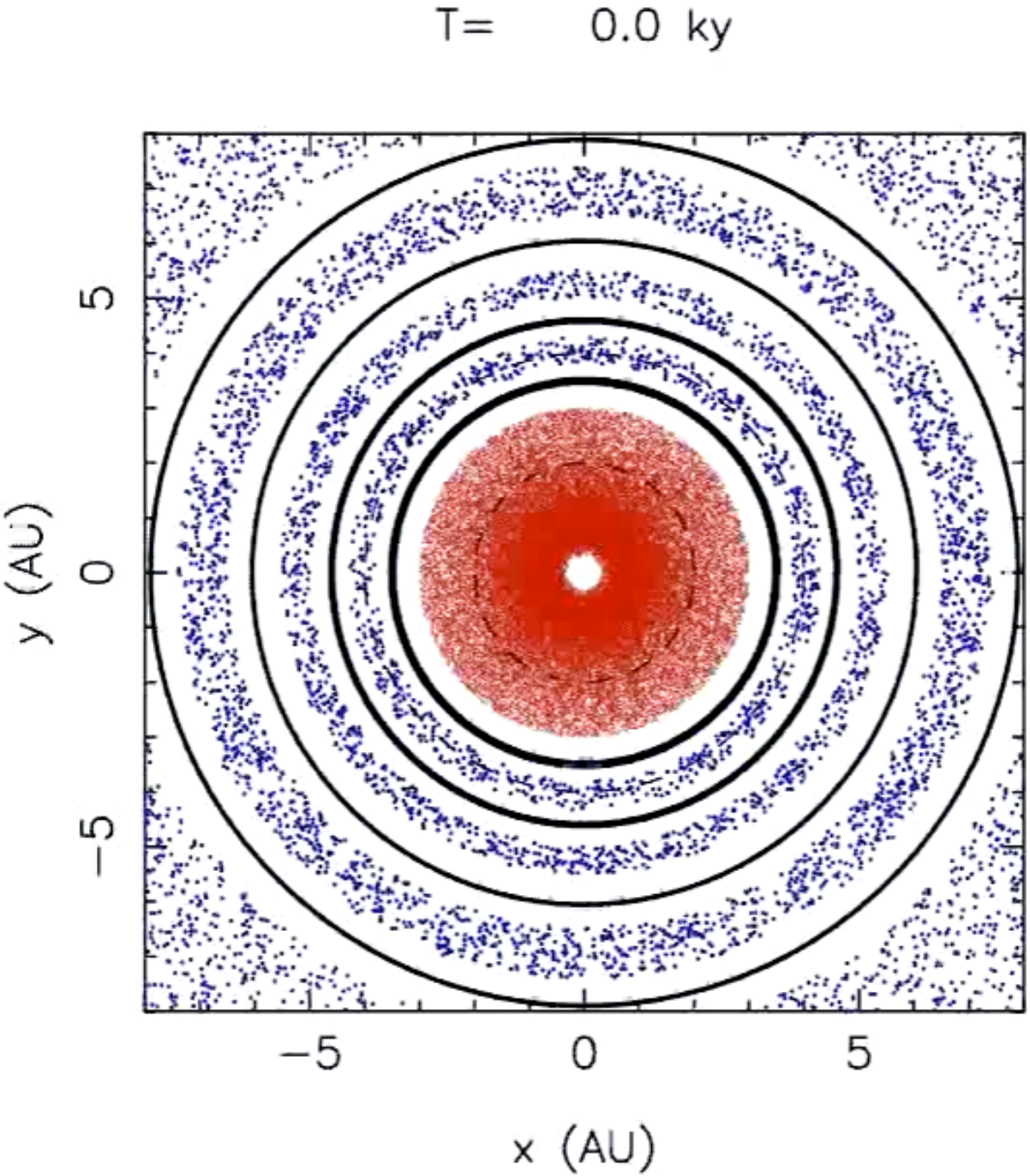
COMET C/2017 U1 (PANSTARRS)

Further observations of this object are very much desired. Unless there are serious problems with much of the astrometry listed below, strongly hyperbolic orbits are the only viable solutions. Although it is probably not too sensible to compute meaningful original and future barycentric orbits, given the very short arc of observations, the orbit below has e ~ 1.2 for both values. If further observations confirm the unusual nature of this orbit, this object may be the first clear case of an interstellar comet.

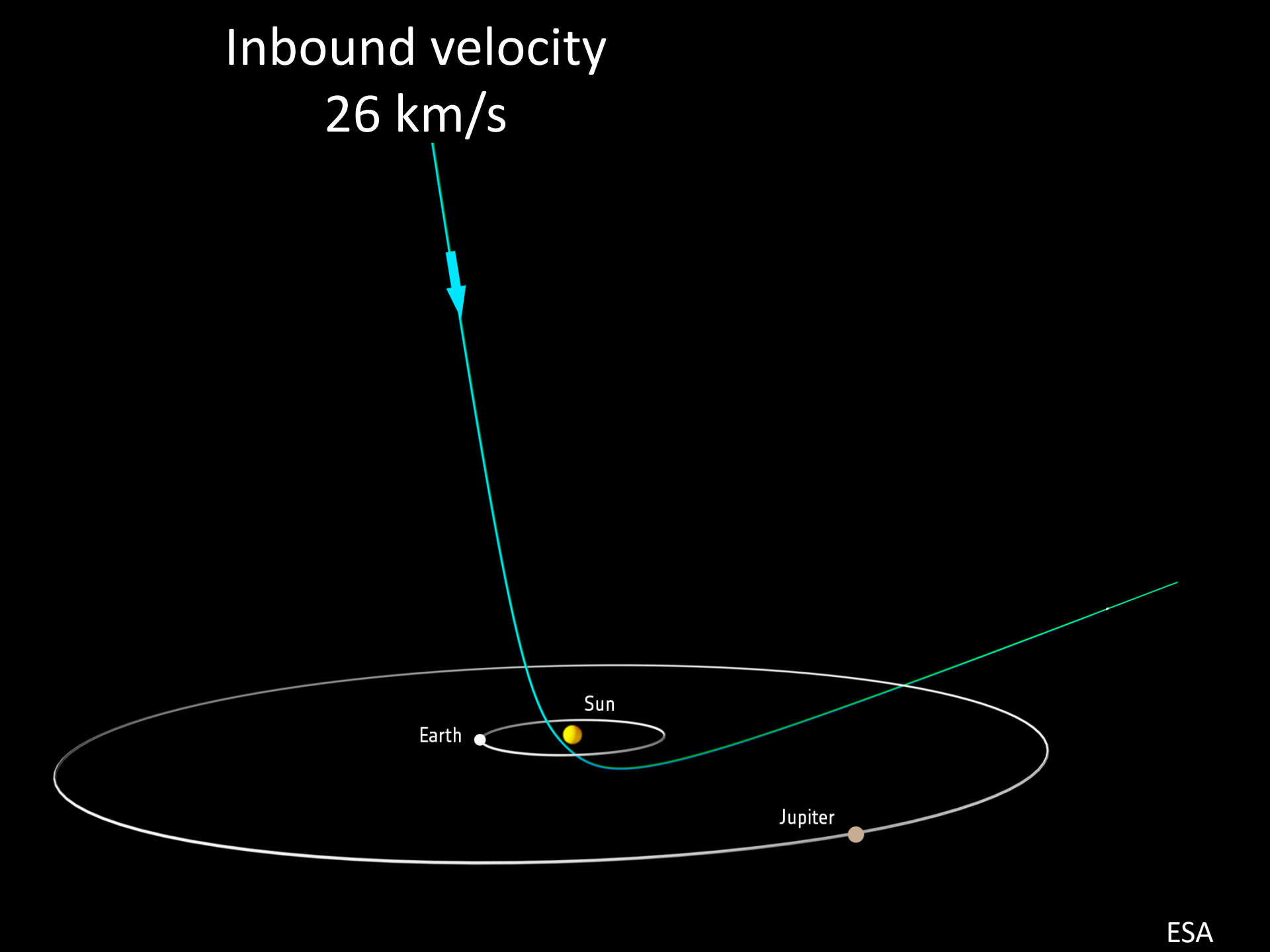
Eccentricity 1.2



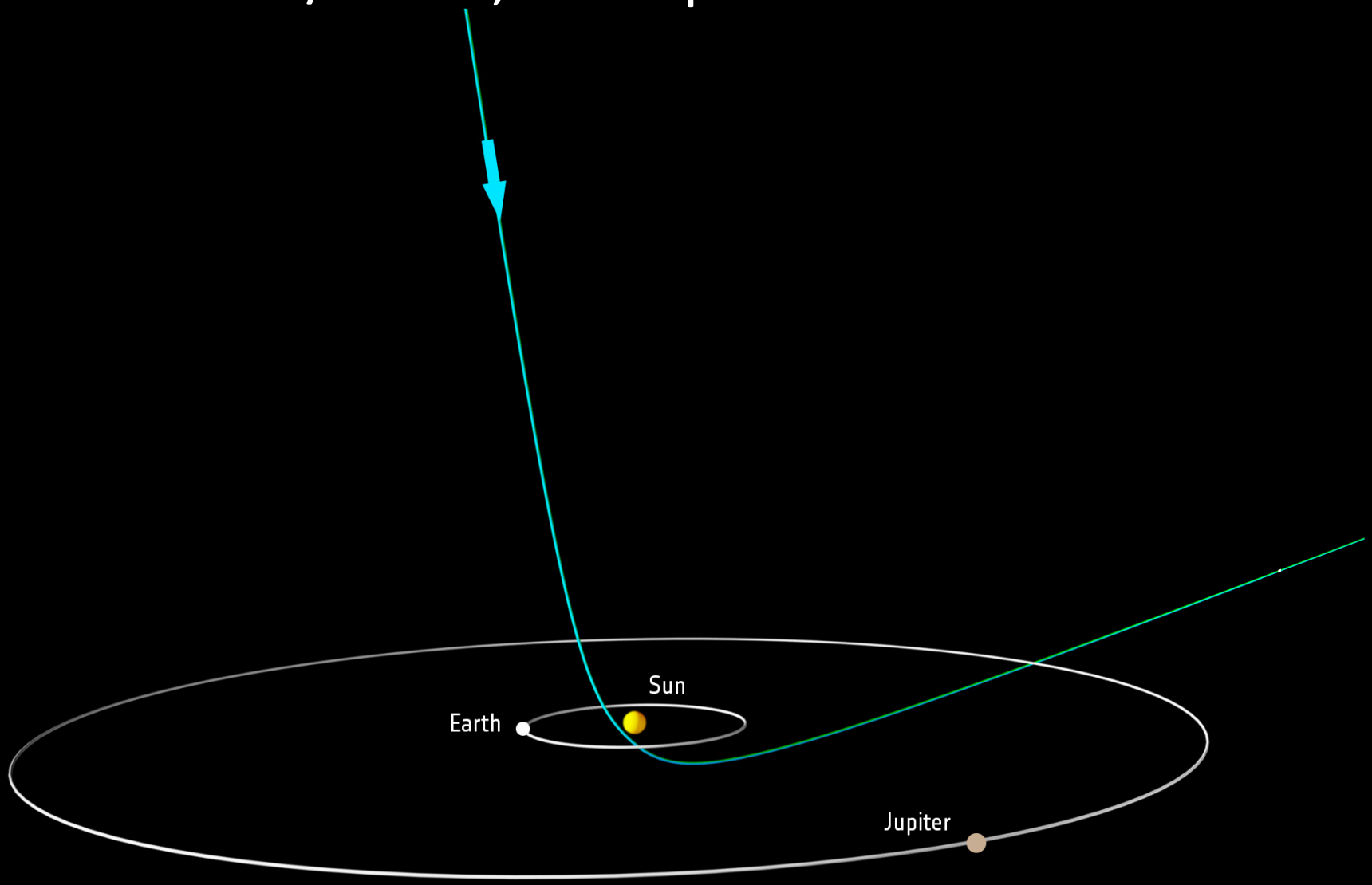
ESA



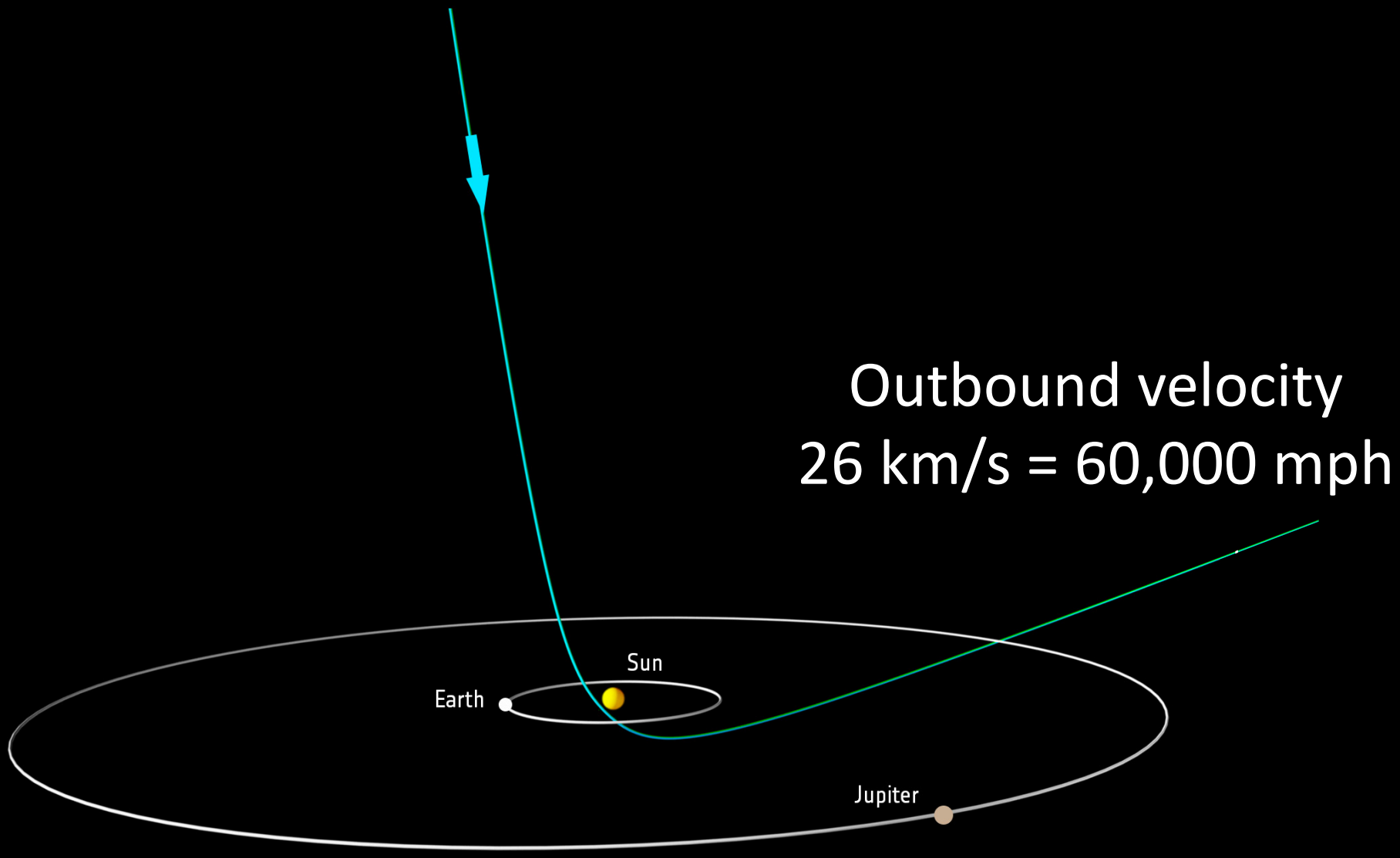
Morbidelli


Inbound velocity
26 km/s
Sun
Earth
Jupiter
ESA

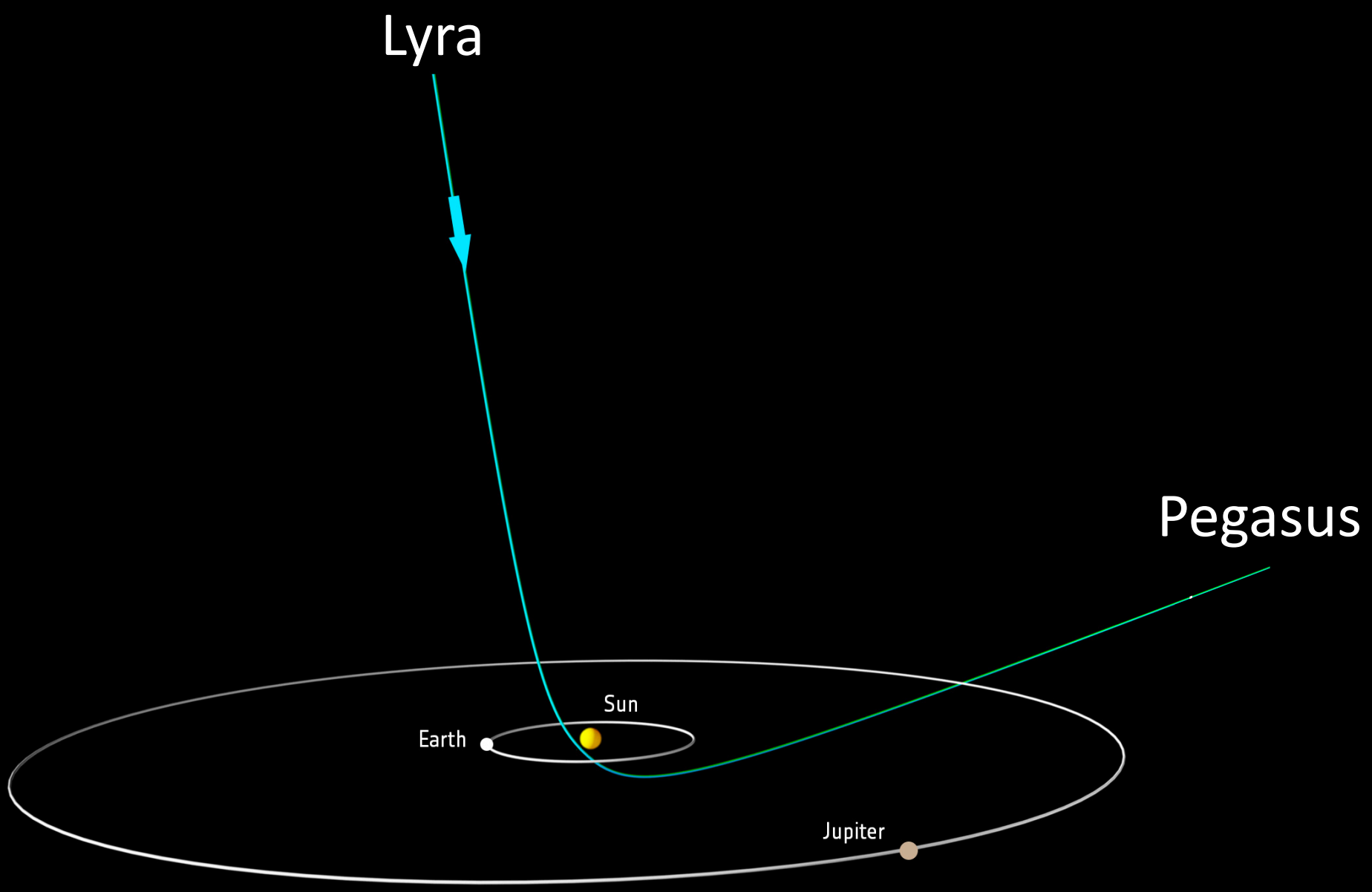
Inbound velocity
26 km/s = 60,000 mph



ESA

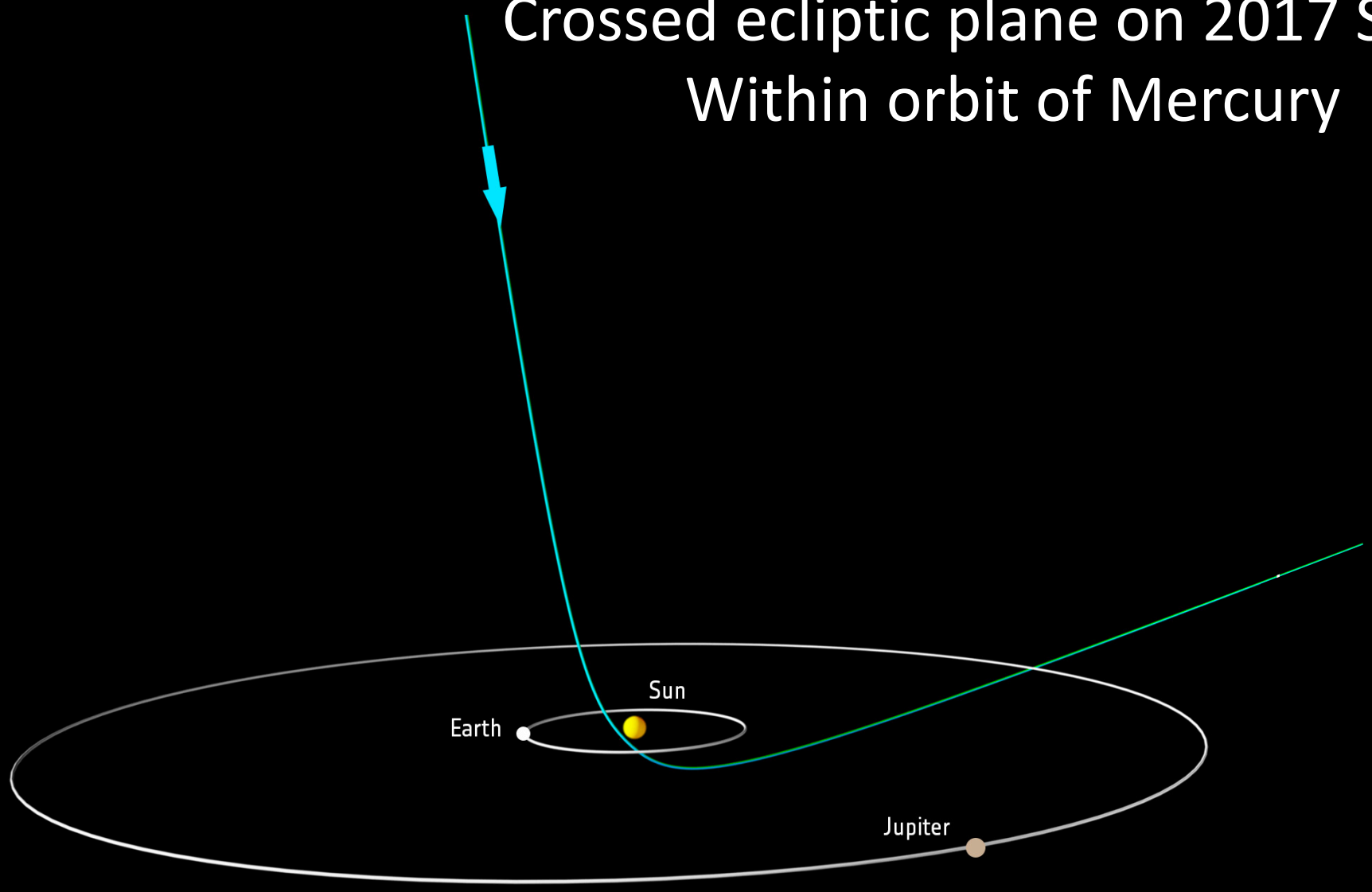


ESA



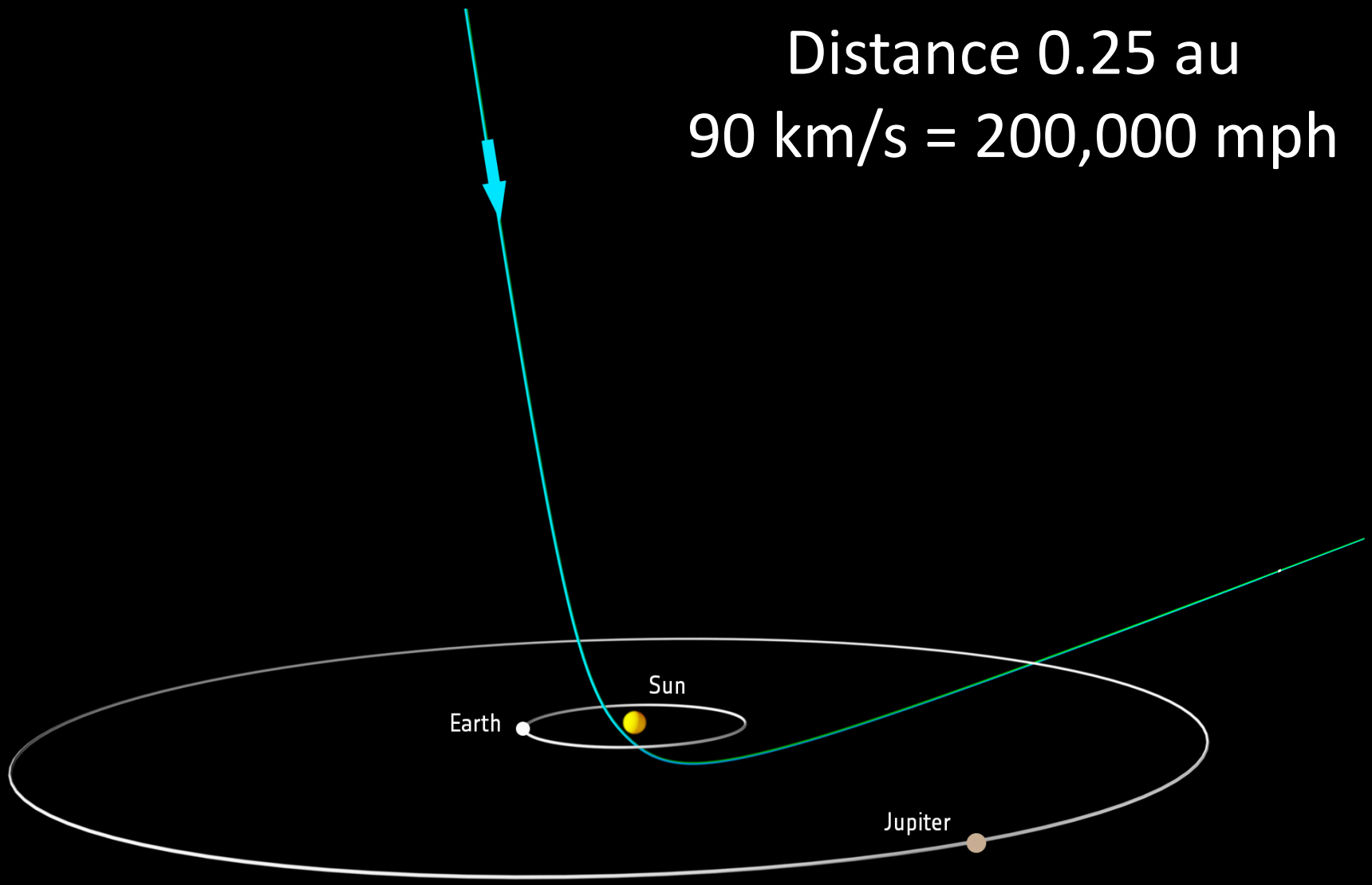
ESA

Crossed ecliptic plane on 2017 Sep.
Within orbit of Mercury

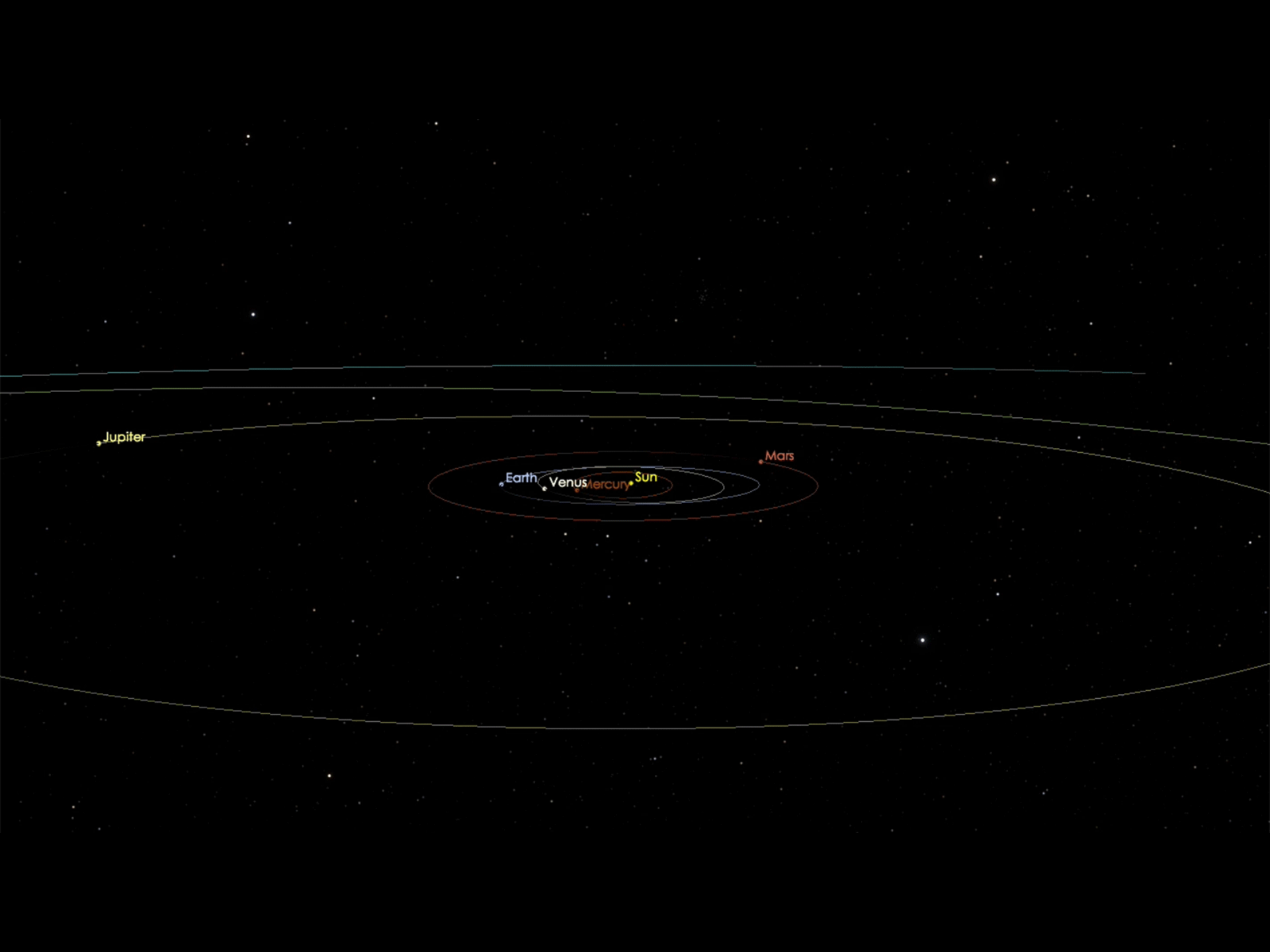


ESA

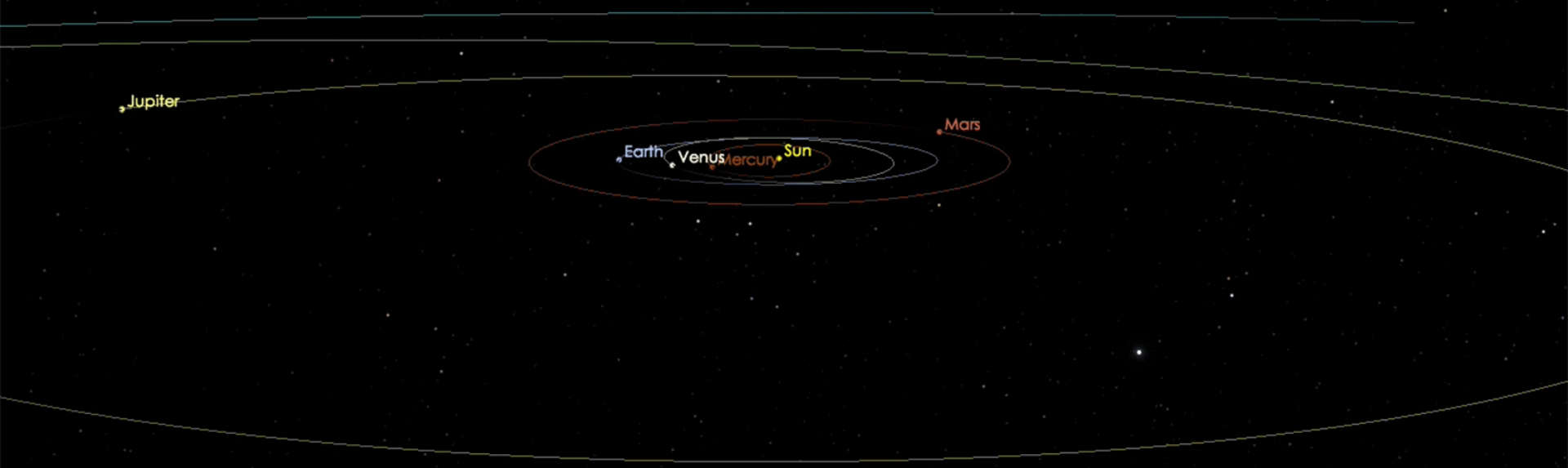
Closest to the Sun on 2017 Sep. 9
Distance 0.25 au
90 km/s = 200,000 mph



ESA


Jupiter
Mars
Earth
Venus
Mercury
Sun

Closest to the Earth on 2017 Oct. 14
Distance 0.16 au = 60 lunar distances
60 km/s = 135,000 mph



Dear Santa,

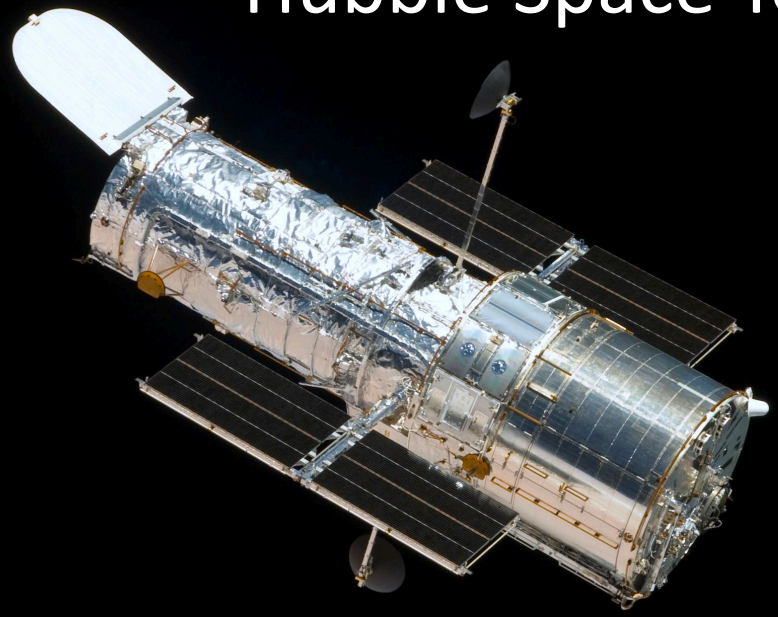
Here is my wish list:

- Size
- Shape
- Mass & Density
- Rotation
- Composition
- Color
- Comet of asteroid?
- Origin

Love

Arctic Ocean
Arctic Ocean
Greenland
Iceland
Finland
Sweden
Norway
Russia
United Kingdom
Poland
Germany
Ukraine
Kazakhstan
Mongolia
France
Italy
Spain
Turkey
China
South Korea
Japan
Iraq
Iran
Afghanistan
Pakistan
Algeria
Libya
Egypt
Saudi Arabia
India
Thailand
Mali
Niger
Chad
Sudan
Nigeria
Ethiopia
Kenya
DRC
Tanzania
Indonesia
Papua New Guinea
Angola
Namibia
Botswana
Madagascar
South Africa
Australia
New Zealand
Venezuela
Colombia
Brazil
Peru
Bolivia
Argentina
North Pacific Ocean
North Atlantic Ocean
South Atlantic Ocean
Indian Ocean
Southern Ocean
Southern Ocean
Palomar
WIYN
APO
DCT
GBT
WHT
NOT
CFHT
Gemini
UKIRT
Keck
VLT
Magellan

Hubble Space Telescope



M.P.E.C. 2017-U183 Issued 2017 Oct. 25, 22:22 UT

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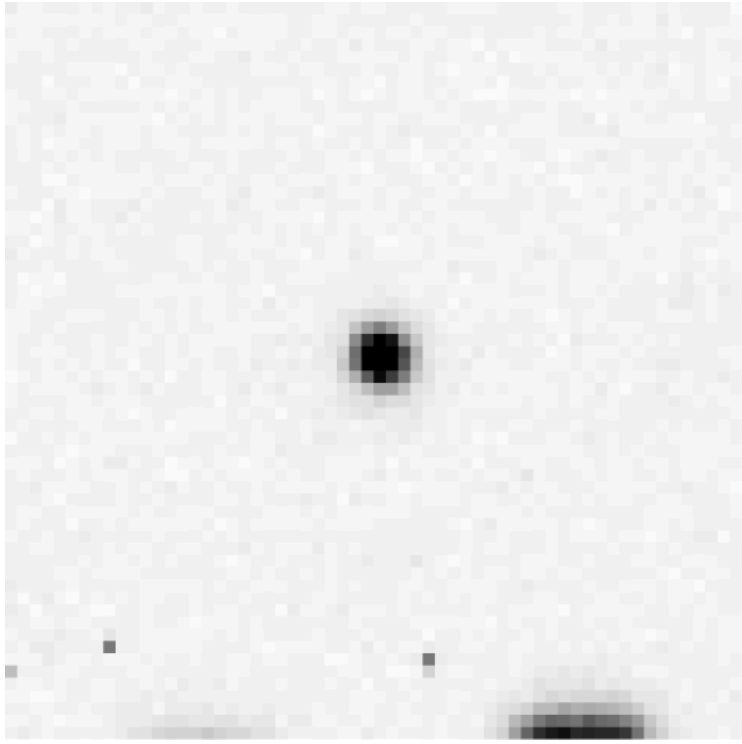
URL https://www.minorplanetcenter.net/ ISSN 1523-6714

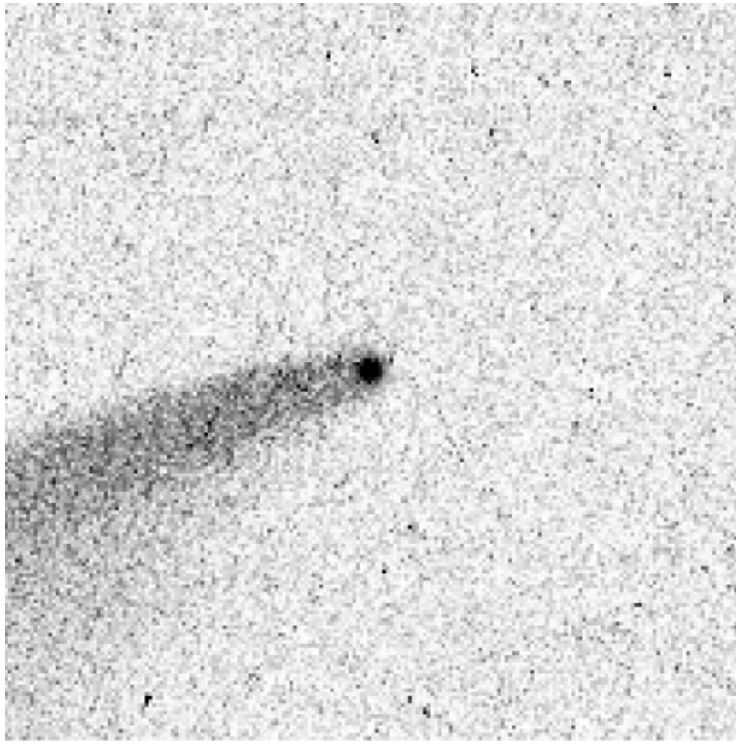
A/2017 U1

K. Meech (Institute of Astronomy, University of Hawaii) reports that in a very deep stacked image, obtained with the VLT, this object appears completely stellar. The prefix for the designation 2017 U1 is therefore being changed to A/, in line with the 1995 IAU Resolution on the system of comet designations.

VLT image of `Oumuamua



Comet with 200 kg of dust



NEW DESIGNATION SCHEME FOR INTERSTELLAR OBJECTS

The discovery of A/2017 U1 has presented a slight nomenclature problem. Since both the original and future barycentric orbits for this object are significantly hyperbolic, this object is not bound to our solar system and the current apparition is likely to be the only time that the object is observable.

Due to the unique nature of this object, there is pressure to assign a name. The minor-planet designation scheme does not allow a name to be assigned to this object based on the brief arc of observation.

Recent e-mail exchanges between the IAU General Secretary, the IAU Division F President, the co-chairs of the IAU Working Group on Small Body Nomenclature and the Minor Planet Center have discussed this nomenclature issue. A solution has been proposed that solves the problem. A new series of small-body designations for interstellar objects will be introduced: the I numbers. This new sequence will be similar in form to the comet numbering system and assignment of the numbers will be handled by the Minor Planet Center.

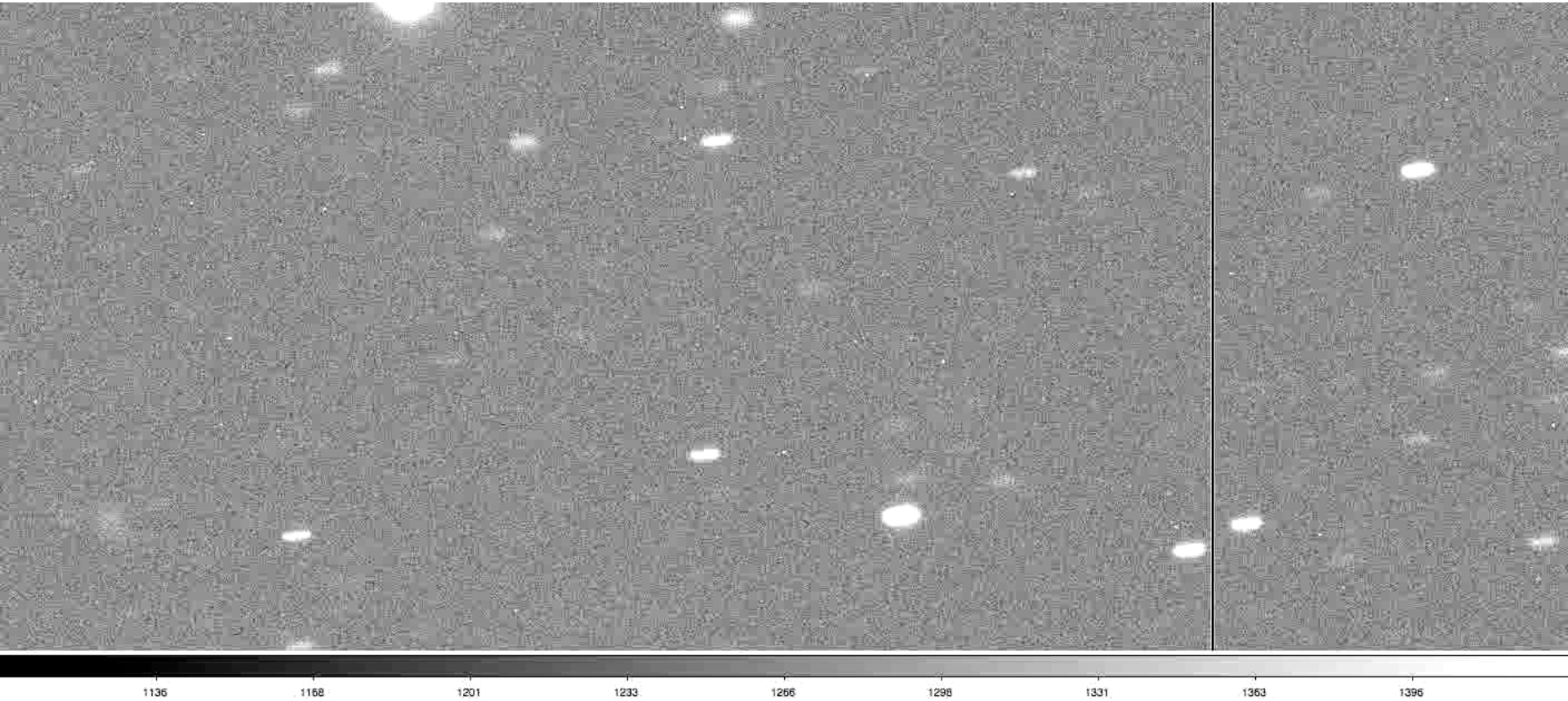
Provisional designations for interstellar objects will be handled using the C/ or A/ prefix (as appropriate), with the designation using the comet system.

Accordingly, the object A/2017 U1 receives the permanent designation 1I and the name ‘Oumuamua. The name, which was chosen by the Pan-STARRS team, is of Hawaiian origin and reflects the way this object is like a scout or messenger sent from the distant past to reach out to us (‘ou means reach out for, and mua, with the second mua placing emphasis, means first, in advance of).

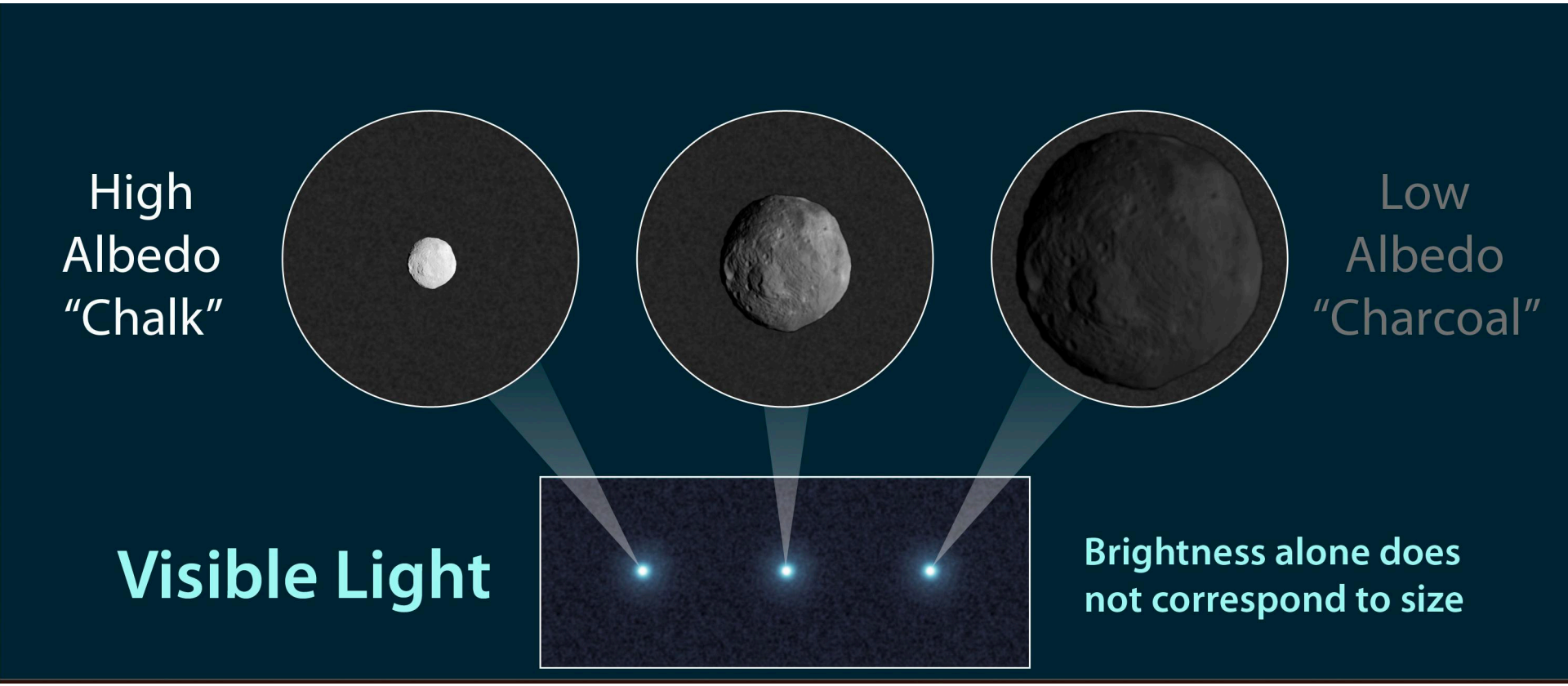
Correct forms for referring to this object are therefore: 1I; 1I/2017 U1; 1I/‘Oumuamua; and 1I/2017 U1 (‘Oumuamua).

43 papers as of July 2018

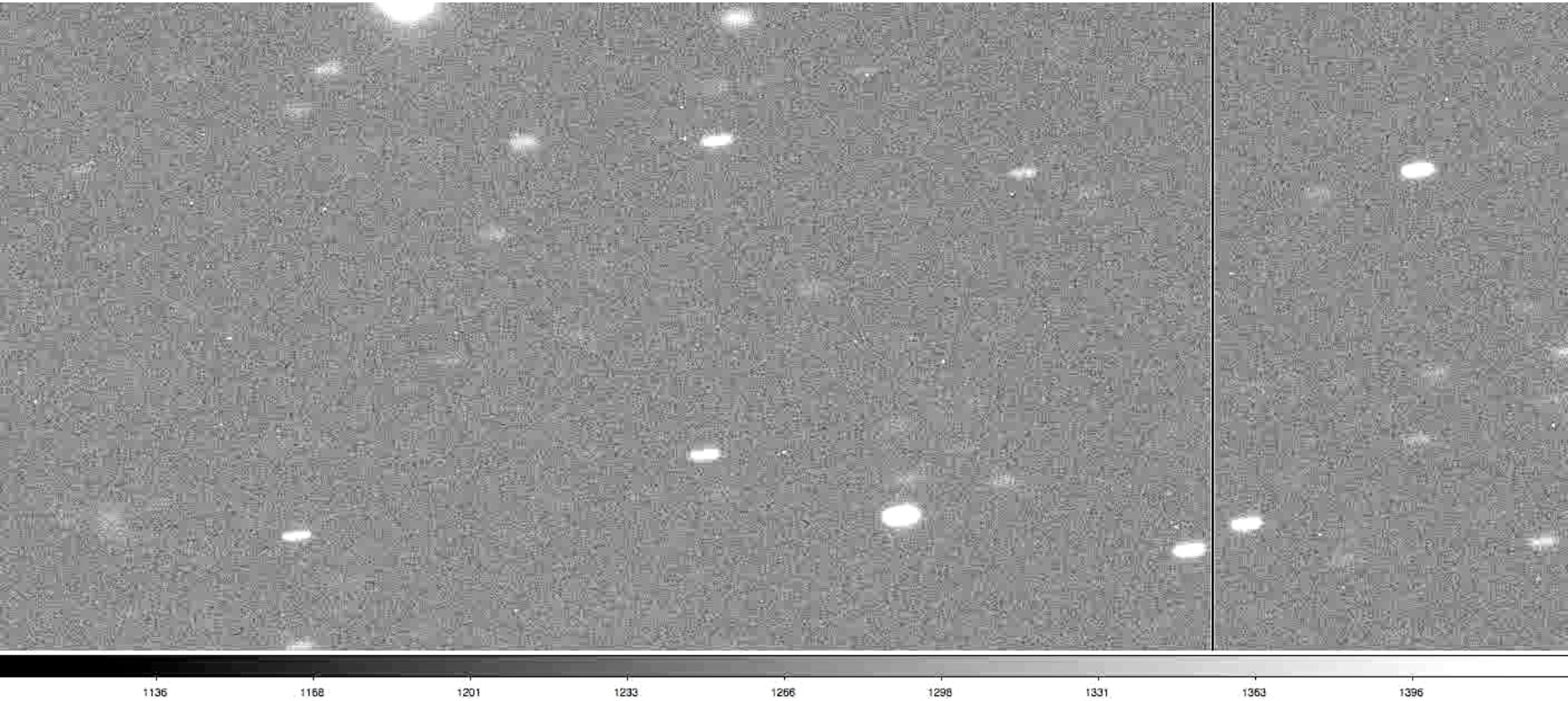
1	2018MNRAS.479L..17P	1.000	09/2018	A	E	F	X		R	C	U
	Portegies Zwart, Simon; Torres, Santiago; Pelupessy, Inti; Bédorf, Jeroen; Cai, Maxwell X.	The origin of interstellar asteroidal objects like 1I/2017 U1 `Oumuamua									
2	2018Icar..311..170K	1.000	09/2018	A	E				R		U
	Kwiecinski, James A.; Krause, Andrew L.; Van Gorder, Robert A.	Effects of tidal torques on 1I/2017 U1 ('Oumuamua)									
3	2018PASJ...70...80T	1.000	08/2018	A	E	F	X		R	C	U
	Tanikawa, Ataru; Suzuki, Takeru K.; Doi, Yasuo	Metal pollution of low-mass Population III stars through accretion of interstellar objects like `Oumuamua									
4	2018MNRAS.tmp.2101A	1.000	08/2018	A	E		X		R		U
	Almeida-Fernandes, F.; Rocha-Pinto, H. J.	A kinematical age for the interstellar object 1I/'Oumuamua									
5	2018MNRAS.478L..95K	1.000	07/2018	A	E	F	X		R	C	U
	Katz, J. I.	Why is interstellar object 1I/2017 U1 (`Oumuamua) rocky, tumbling and possibly very prolate?									
6	2018MNRAS.478L..49J	1.000	07/2018	A	E	F	X		R	C	U
	Jackson, Alan P.; Tamayo, Daniel; Hammond, Noah; Ali-Dib, Mohamad; Rein, Hanno	Ejection of rocky and icy material from binary star systems: implications for the origin and composition of 1I/`Oumuamua									
7	2018MNRAS.477.5692G	1.000	07/2018	A	E	F	X		R	C	U
	Gaidos, E.	What and whence 1I/`Oumuamua: a contact binary from the debris of a young planetary system?									
8	2018ApJ...861...35R	1.000	07/2018	A	E	F	X		R	C	U
	Rafikov, Roman R.	1I/2017 'Oumuamua-like Interstellar Asteroids as Possible Messengers from Dead Stars									
9	2018Natur.559..223M	1.000	06/2018	A	E			D	R	C	U
	Micheli, Marco; Farnocchia, Davide; Meech, Karen J.; Buie, Marc W.; Hainaut, Olivier R.; Prialnik, Dina; Schörghofer, Norbert; Weaver, Harold A.; Chodas, Paul W.; Kleyna, Jan T.; and 7 coauthors	Non-gravitational acceleration in the trajectory of 1I/2017 U1 ('Oumuamua)									
10	2018MNRAS.477L..85J	1.000	06/2018	A					R	C	U



Wainscoat



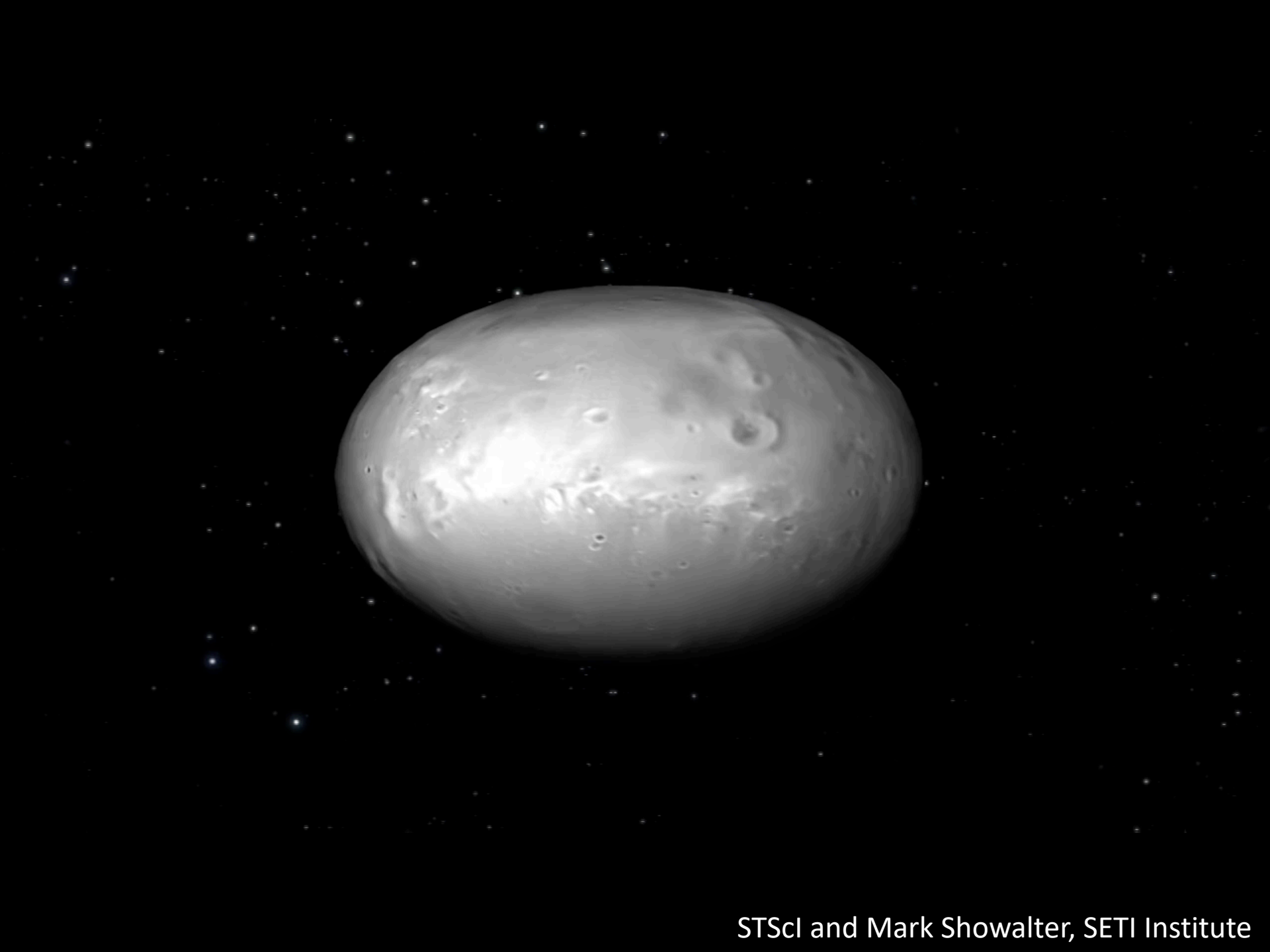
Effective diameter 200 m for 4% albedo



Wainscoat

ISAS / JAXA / Øyvind Guldbrandsen

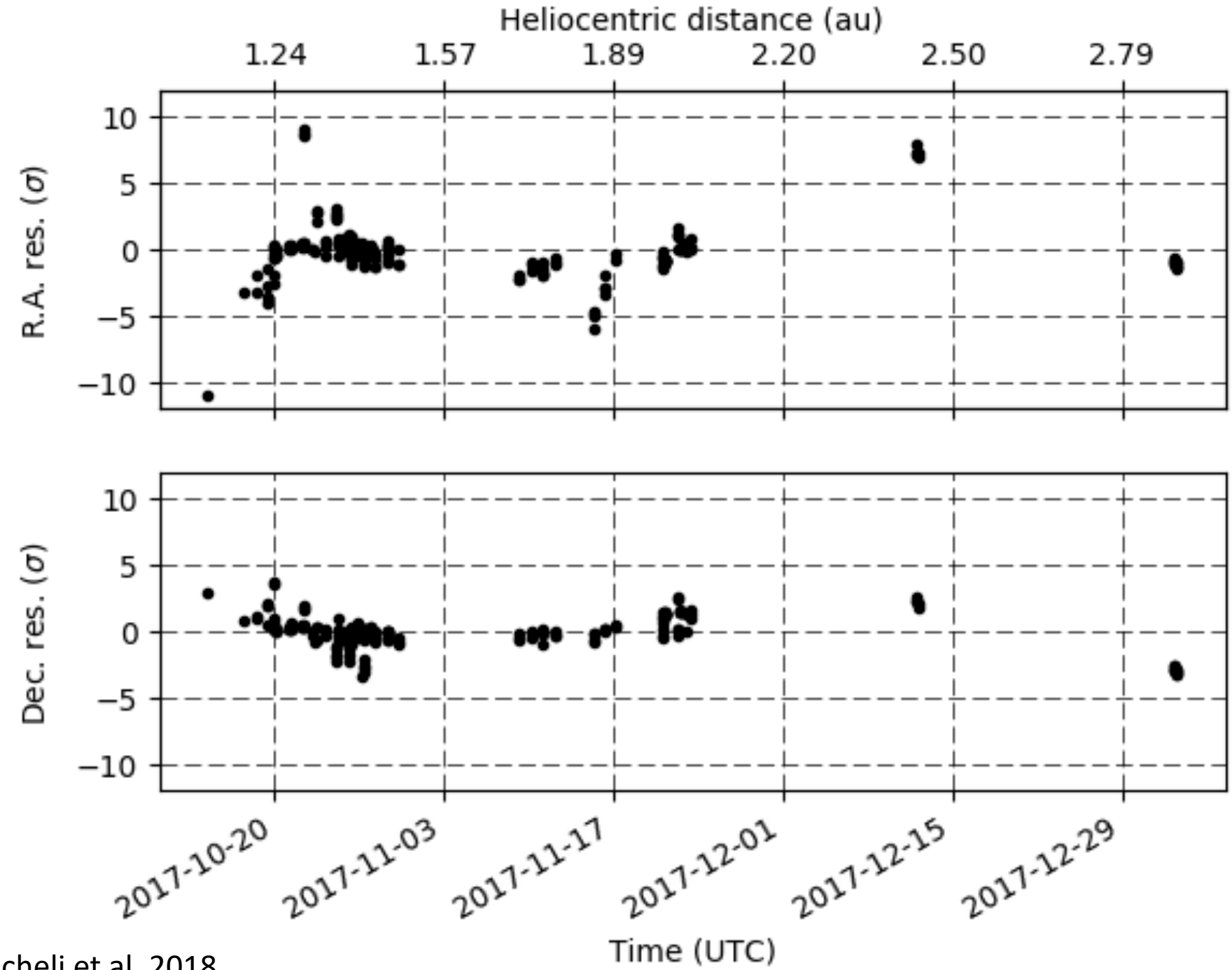
Rotation period ~ 7.34 h



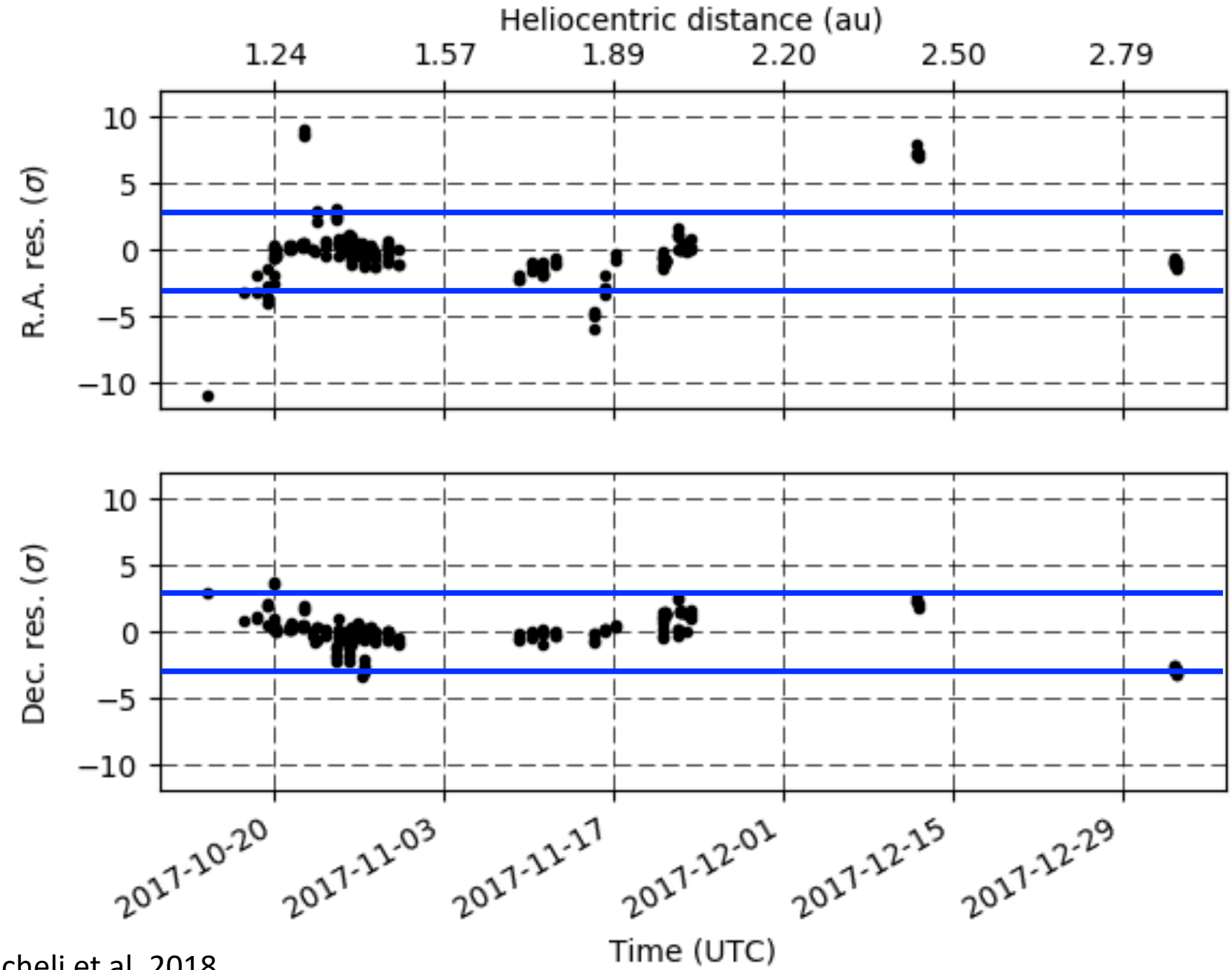
STScI and Mark Showalter, SETI Institute

ESO

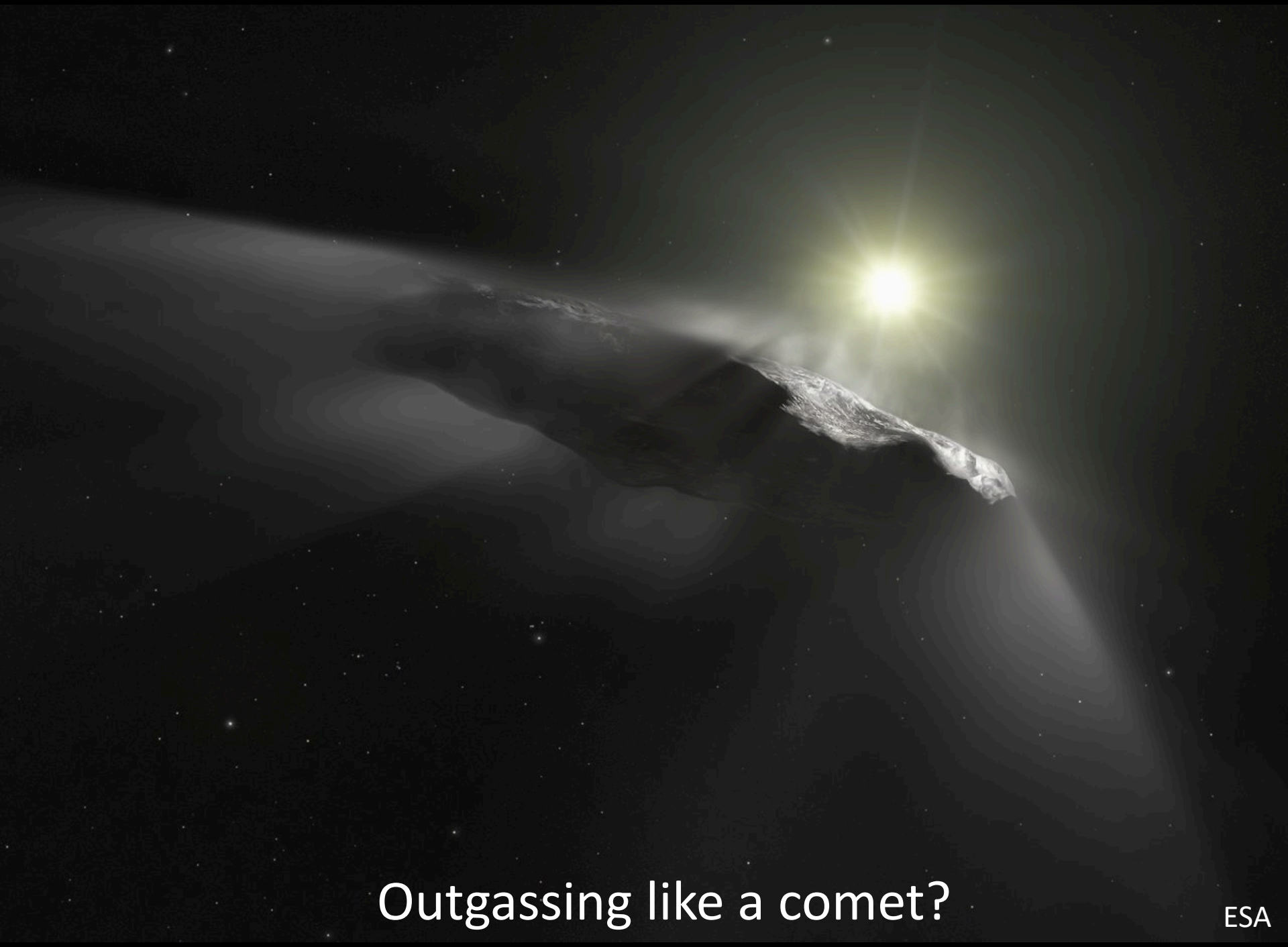
Wm K Hartmann
Mar 2018

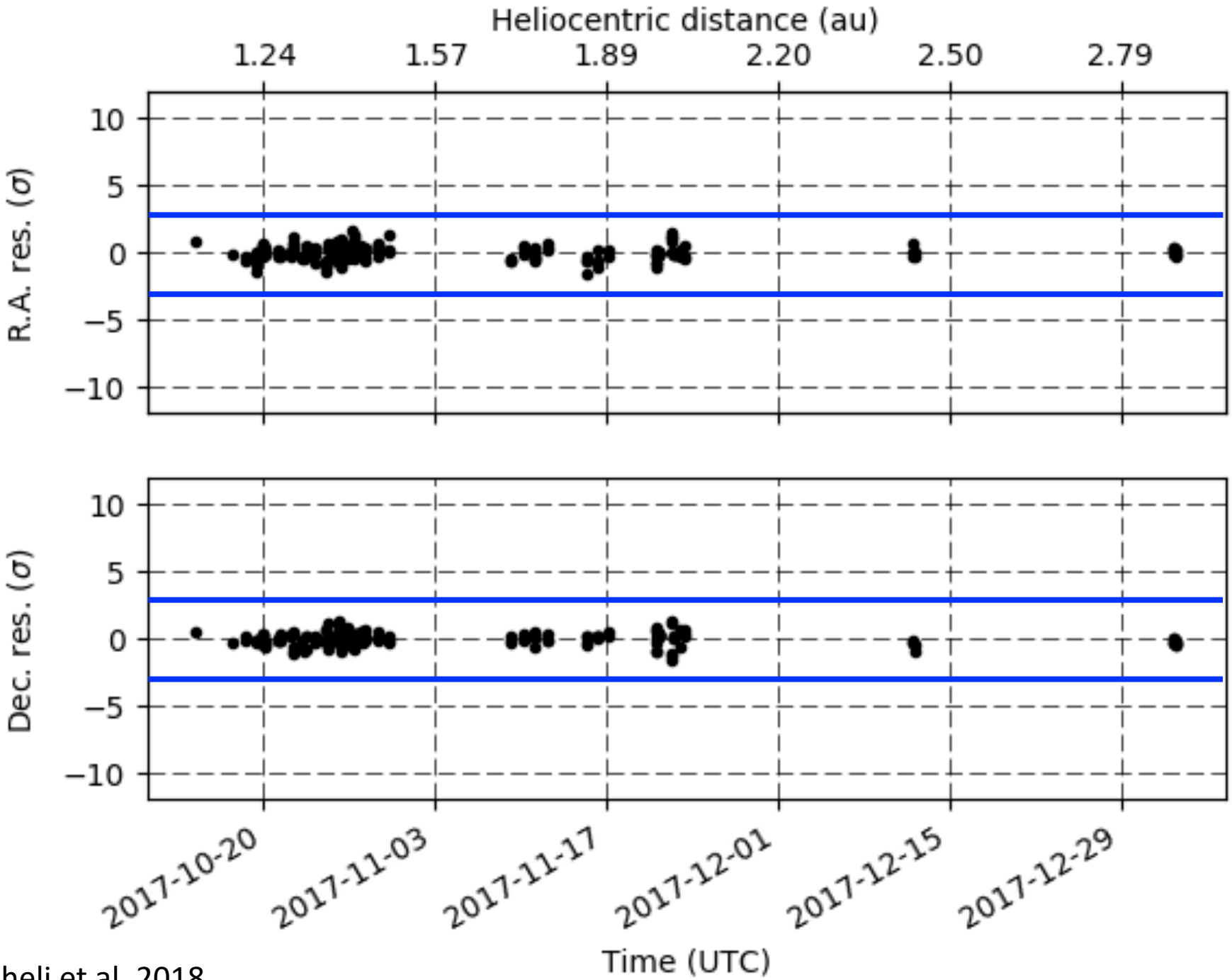


Micheli et al. 2018

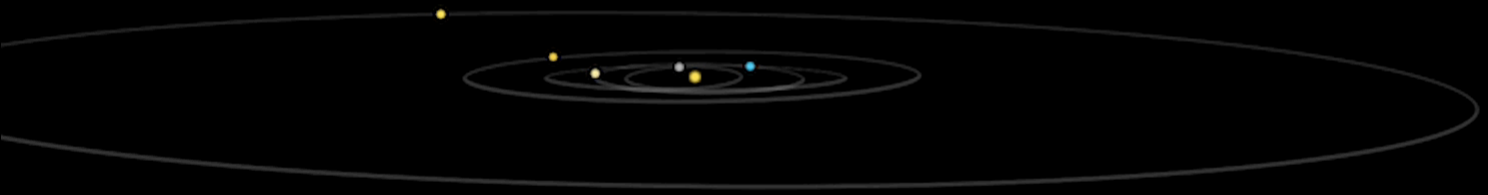


Micheli et al. 2018


Outgassing like a comet?
ESA



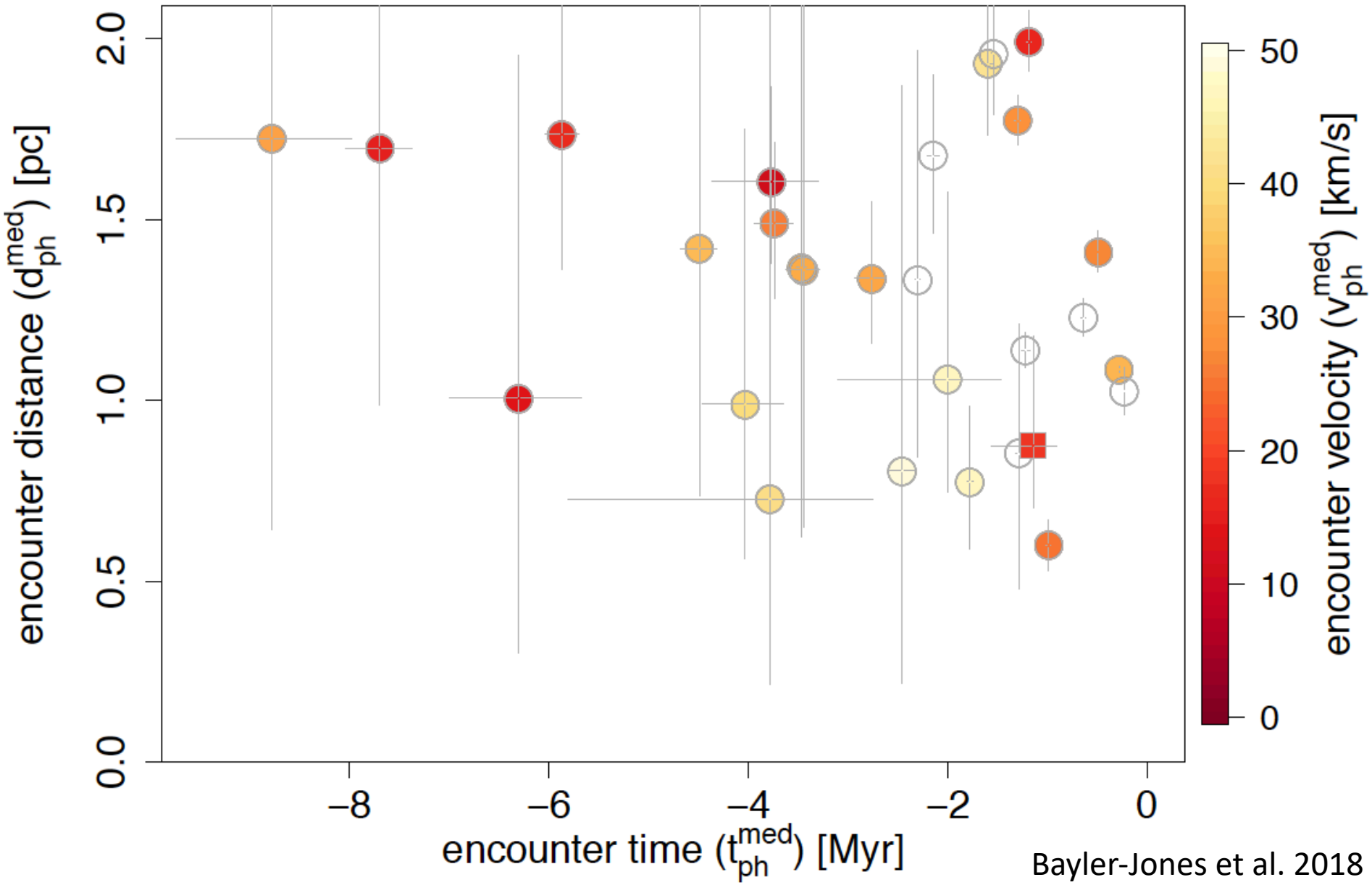
Micheli et al. 2018



Coryn Bayler-Jones

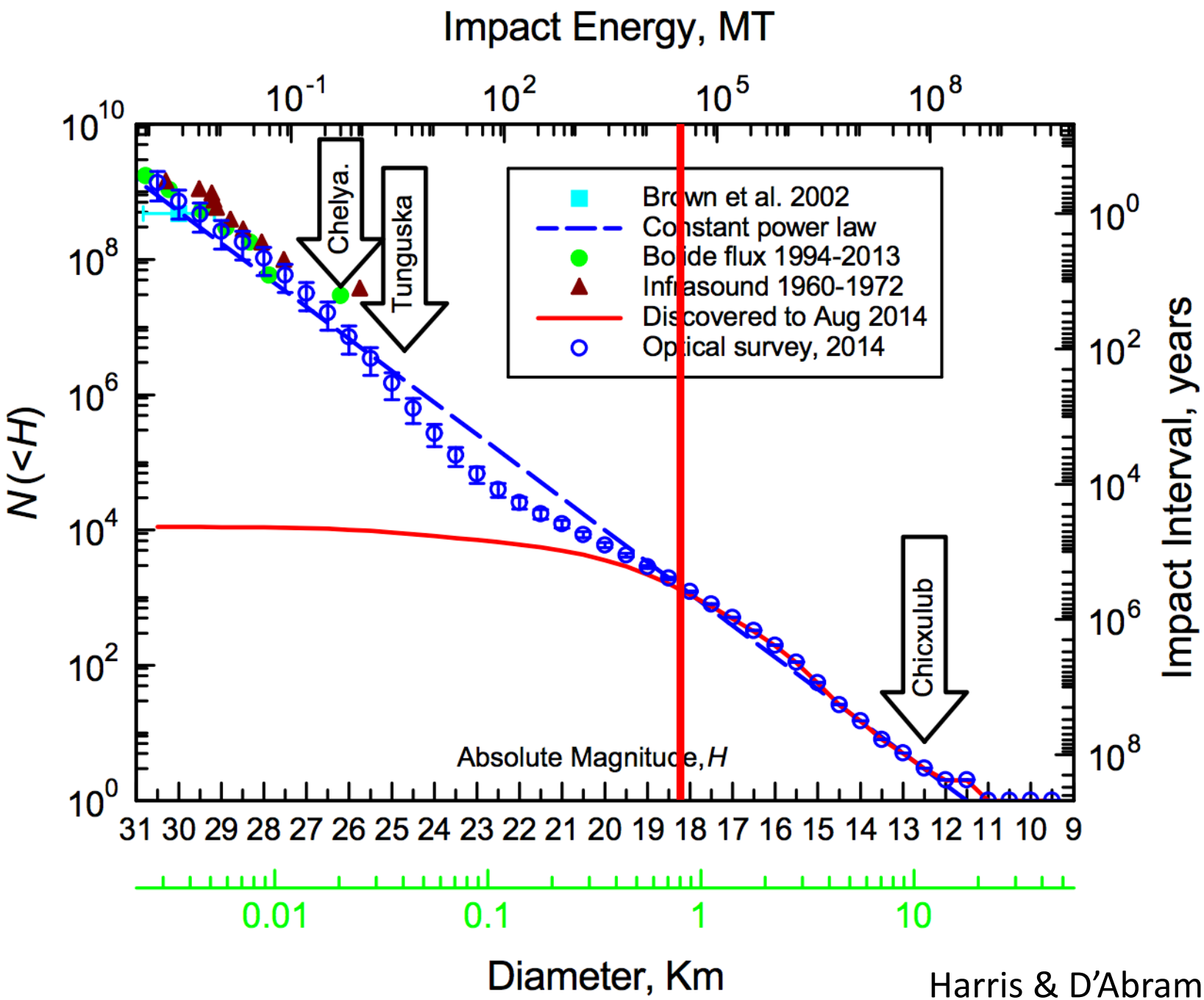
Backup slides

Where did it come from?



Bayler-Jones et al. 2018

Date	V wrt Sun	V wrt Earth	Energy [Mton]	x Hiroshima	x KT impact
Sep 9, 2017	87 km/s	68.3 km/s	17,900	1.2 million	0.0007
Oct 14, 2017	48 km/s	60 km/s	14,000	1 million	0.0006



Harris & D'Abramo, 2015

Breakthrough Listen Observations of 1I/'Oumuamua with the GBT

Breakthrough Listen Observations of 1I/'Oumuamua with the GBT - IOPscience

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References Citations

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1. Introduction

On 2017 October 18, the Pan-STARRS collaboration discovered an object within our solar system that appeared to be on a hyperbolic orbit (Williams 2017). Subsequent observations suggest this object (now designated 1I/2017 U1 or 1I/'Oumuamua) is of interstellar origin, lacks a coma, and that its shape is highly elongated relative to other known asteroids (Meech et al. 2017).

It has long been suggested that advanced extraterrestrial civilizations, should they exist, could conceivably send probes to other stars either for exploration or communication purposes (Bracewell 1960; Freitas 1980; Rose & Wright 2004; Gertz 2016). Interstellar probes would likely be equipped with communication technology that could potentially be operating in the radio band.

The Breakthrough Listen (BL) program (Worden et al. 2017) conducted an observing campaign targeting 1I/'Oumuamua with the Robert C. Byrd Green Bank Telescope (GBT), with a goal of detecting, or placing limits on, radio emission consistent with a technological source. Because