Stellar occultations by 2002 MS_4: preliminary results

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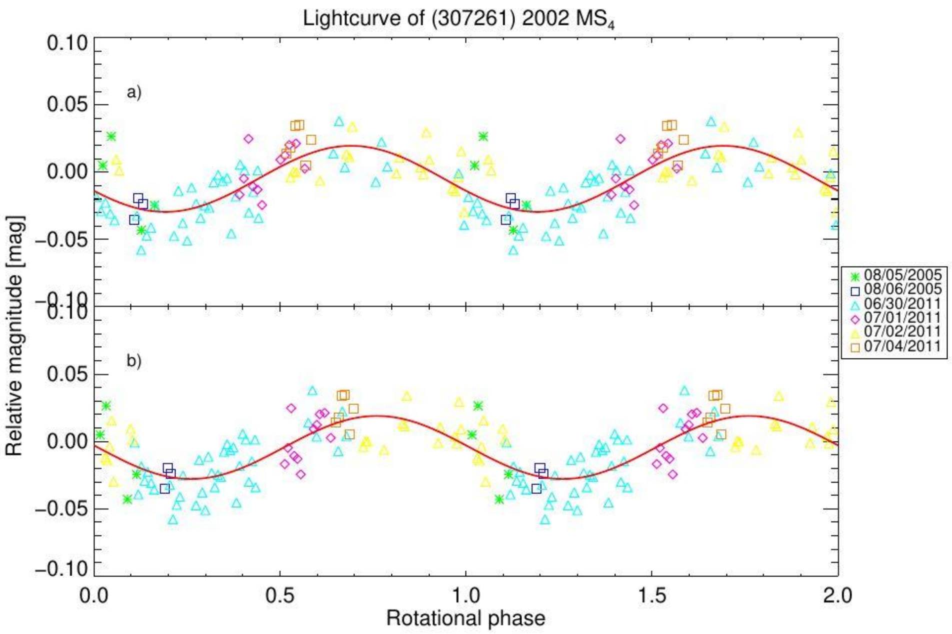
ESOP XL POLAND 2021

(307261) 2002 MS_4

- Discovered by the Near-Earth Asteroid (NEAT) program on 18 June 2002;
- Hot classical TNO (Gladman et al. 2008);
- Dwarf planet candidate (Vilenius et al. 2012):
  - R = 467 ± 23.5 km;
  - ϱ_v = 0.051;
  - H_v = 4.0 mag;
- Rotation (Thirouin, A. 2013):
  - P = 7.33 h or 10.44 h;
  - Amplitude = 0.05 ± 0.01 mag;



Reproduced from Thirouin, A. 2013.

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Stellar occultations by 2002 MS_4

- 09/07/2019 -------> Double-chord (South America);
- 26/07/2019 -------> Triple-chord (South America);
- 26/07/2019 -------> Single-chord (North America);
- 19/08/2019 -------> Double-chord (North America);
- 26/07/2020 -------> Double-chord (South Africa);
- 08/08/2020 -------> Multichord (Europe, North Africa, and Western Asia);
- 24/02/2021 -------> Double-chord (South America).

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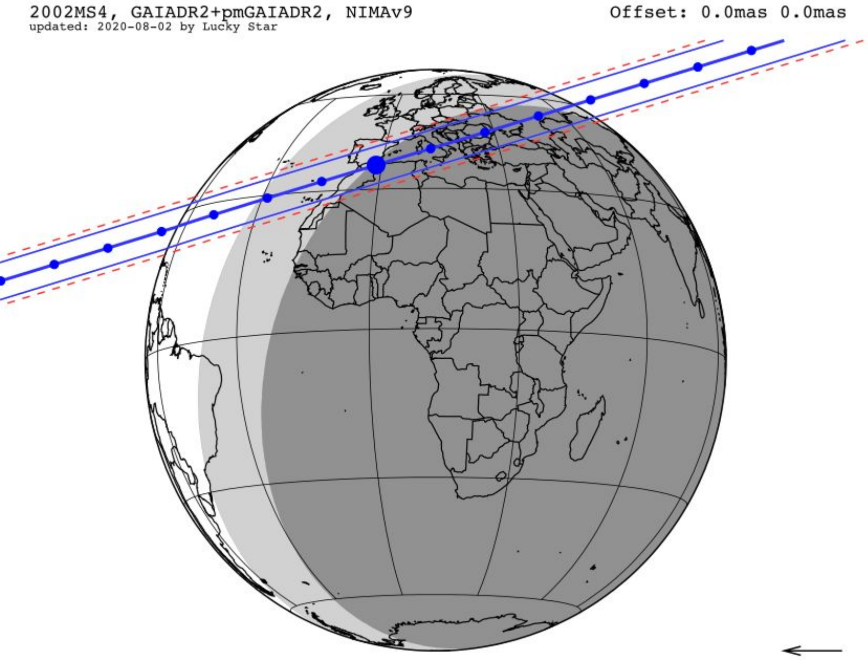
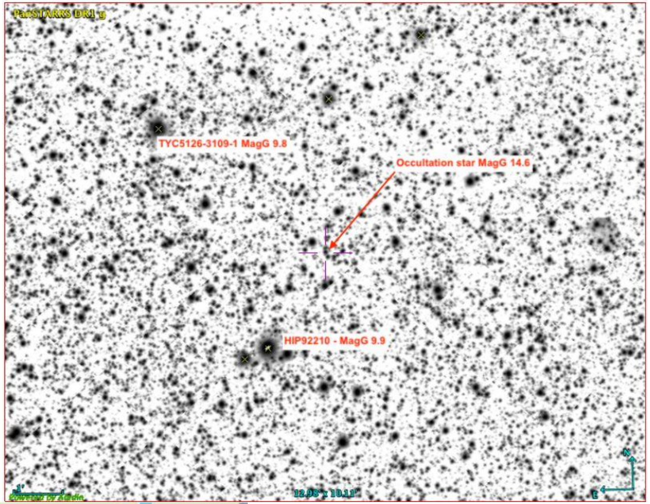
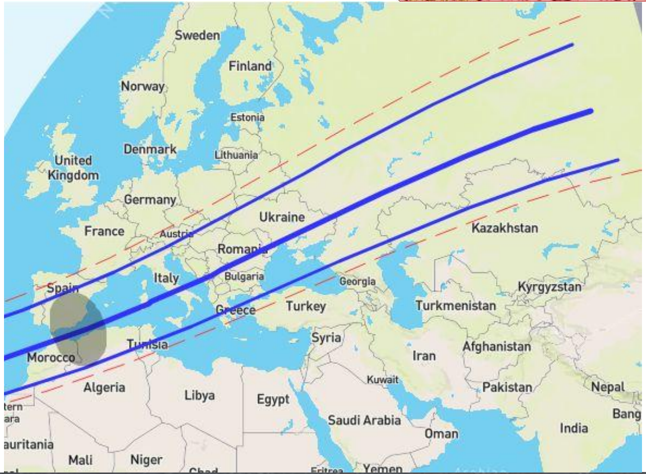
8 August 2020
Prediction and campaign



yyyy mm dd hh:mm:ss.s	RA_star_J2000	DE_star_J2000	C/A	P/A	vel	Delta	G*	RP*	H*
2020-08-08 20:44:28.4	18 47 29.9638	-06 16 31.473	0.135	342.96	-20.53	45.6939	14.7	13.6	11.3





mag drop = 5.7
max. duration = 38 s

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8 August 2020 - 116 telescopes

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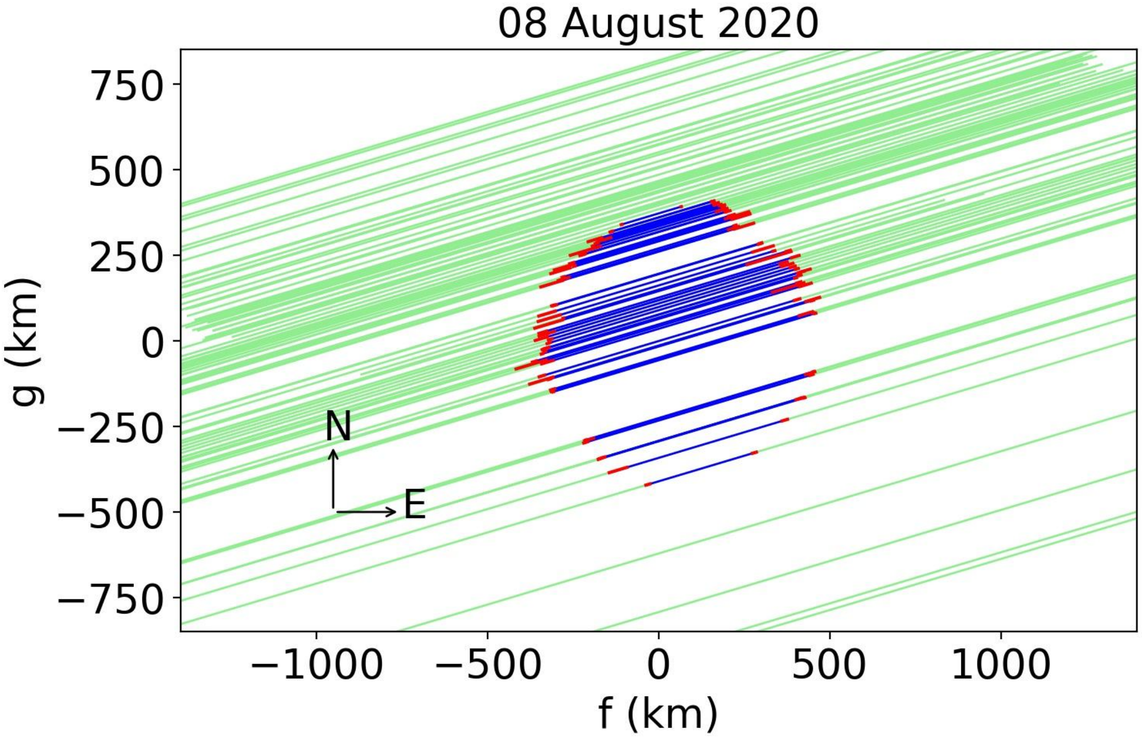
Projected chords

- 61 positives
- 40 negatives
- 15 bad weather
- No secondary events detected;



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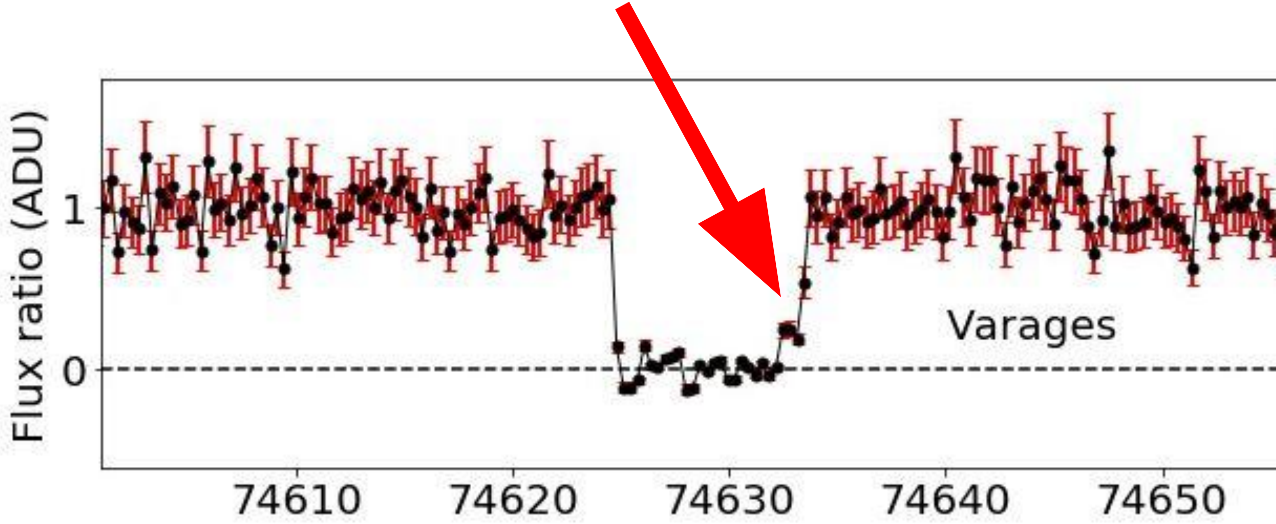
Detected topography (~25 km)

- Light curve from Varages - France;
- by Jean Lecacheux
- WATEC 910HX;
- GPS;
- EXP: 0.32 s;
- 0.5 m telescope;



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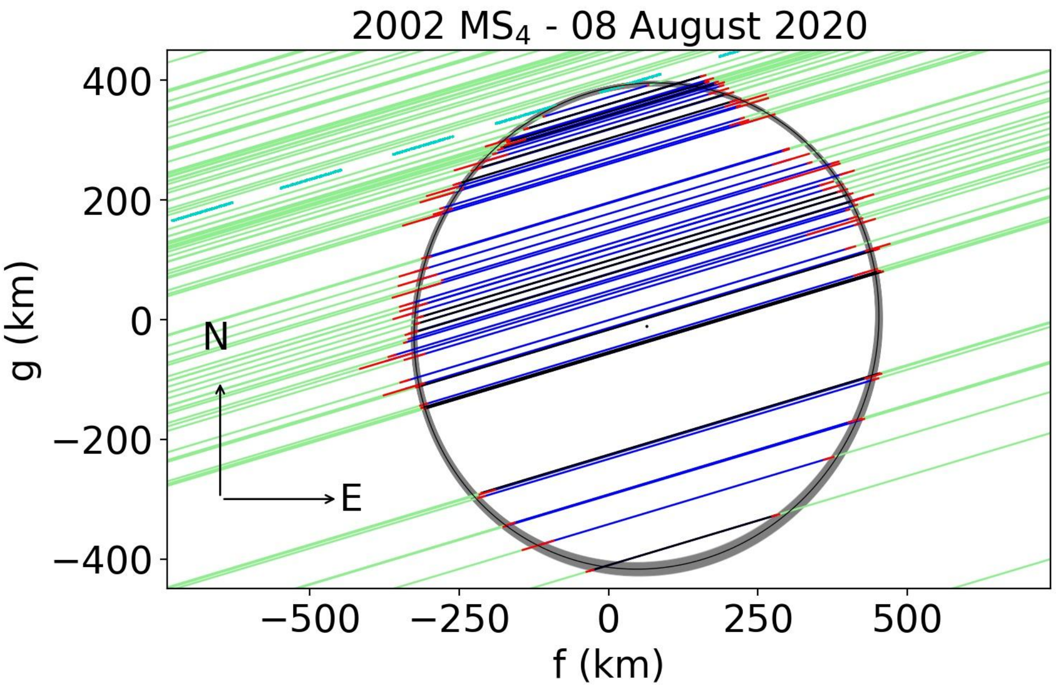
Ellipse search



- a’ = 413.7 ± 9.6 km;
- ϵ’ = 0.067 ± 0.033;
- R_{equiv} = 399.6 ± 11.7 km;

Diameter about 130 km smaller than the results from thermal data.

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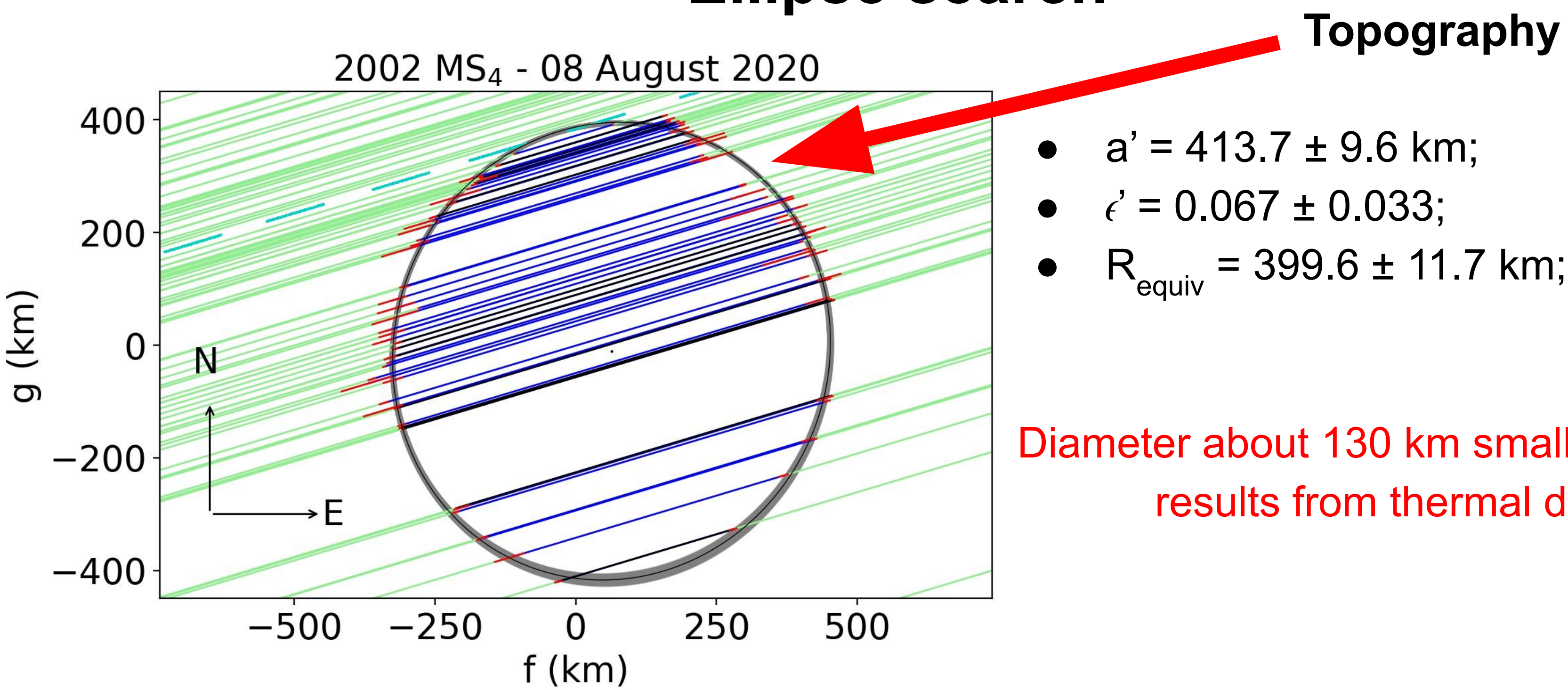

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Topography studies from literature

- Pluto system (Moore et al. 2016; Nimmo et al. 2017);

RESEARCH

RESEARCH ARTICLES

PLANETARY SCIENCE

The geology of Pluto and Charon through the eyes of New Horizons

Jeffrey M. Moore,[1*] William B. McKinnon,[2] John R. Spencer,[3] Alan D. Howard,[4] Paul M. Schenk,[5] Ross A. Beyer,[6,1] Francis Nimmo,[7] Kelsi N. Singer,[3] Orkan M. Umurhan,[1] Oliver L. White,[1] S. Alan Stern,[3] Kimberly Ennico,[1] Cathy B. Olkin,[3] Harold A. Weaver,[8] Leslie A. Young,[3] Richard P. Binzel,[9] Marc W. Buie,[3] Bonnie J. Buratti,[10] Andrew F. Cheng,[8] Dale P. Cruikshank,[1] Will M. Grundy,[11] Ivan R. Linscott,[12] Harold J. Reitsema,[3] Dennis C. Reuter,[13] Mark R. Showalter,[6] Veronica J. Bray,[14] Carrie L. Chavez,[6,1] Carly J. A. Howett,[3] Tod R. Lauer,[15] Carey M. Lisse,[8] Alex Harrison Parker,[3] S. B. Porter,[3] Stuart J. Robbins,[3] Kirby Runyon,[8] Ted Stryk,[16] Henry B. Throop,[17] Constantine C. C. Tsang,[3] Anne J. Verbiscer,[18] Amanda M. Zangari,[3] Andrew L. Chaikin,[19] Don E. Wilhelms,[20] New Horizons Science Team

NASA's New Horizons spacecraft has revealed the complex geology of Pluto and Charon. Pluto's encounter hemisphere shows ongoing surface geological activity centered on a vast basin containing a thick layer of volatile ices that appears to be involved in convection and advection, with a crater retention age no greater than ~10 million years. Surrounding terrains show active glacial flow, apparent transport and rotation of large buoyant water-ice crustal blocks, and pitting, the latter likely caused by sublimation erosion and/or collapse. More enigmatic features include tall mounds with central depressions that are conceivably cryovolcanic and ridges with complex bladed textures. Pluto also has ancient cratered terrains up to ~4 billion years old that are extensionally faulted and extensively mantled and perhaps eroded by glacial or other processes. Charon does not appear to be currently active, but experienced major extensional tectonism and resurfacing (probably cryovolcanic) nearly 4 billion years ago. Impact crater populations on Pluto and Charon are not consistent with the steepest impactor size-frequency distributions proposed for the Kuiper belt.

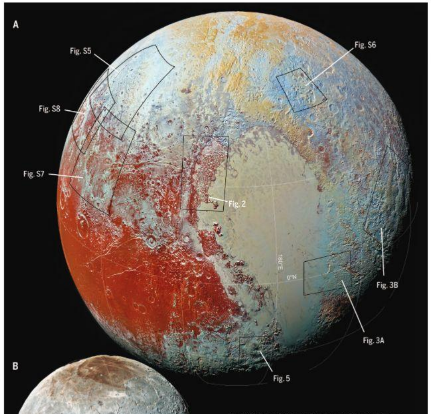

Fig. 1. Global, enhanced color views of Pluto and Charon, with their relative sizes shown to scale. Filters used are blue-red-near infrared (23). (A) Pluto's diameter is 2374 km, and (B) Charon's is 1212 km (5). The spacing of the latitude and longitude lines is 30°. Pluto image is 680 m/pixel MVIC coverage of the P_COLOR2 observation, with a subspacecraft position of 26.6°N, 167.6°E and a phase angle of 38.0°. Charon image is 1460 m/pixel MVIC coverage of the C_COLOR_2 observation, with a subspacecraft position of 25.5°N, 347.5°E and a phase angle of 38.3°. North is up for both. A number of terrains shown in other figures are highlighted and labeled.

Icarus 287 (2017) 12–29

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journal homepage: www.elsevier.com/locate/icarus

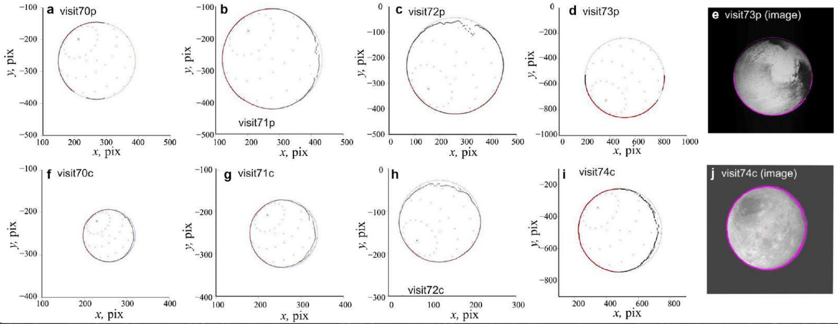
ELSEVIER

Mean radius and shape of Pluto and Charon from *New Horizons* images

CrossMark

Francis Nimmo[a,*], Orkan Umurhan[b], Carey M. Lisse[c], Carver J. Bierson[a], Tod R. Lauer[d], Marc W. Buie[e], Henry B. Throop[f], Josh A. Kammer[e], James H. Roberts[c], William B. McKinnon[g], Amanda M. Zangari[e], Jeffrey M. Moore[b], S. Alan Stern[e], Leslie A. Young[e], Harold A. Weaver[c], Cathy B. Olkin[e], Kim Ennico[b]

[a] Department of Earth and Planetary Sciences, University of California Santa Cruz, Santa Cruz, CA 95064, United States
[b] NASA Ames Research Center, Moffett Field, CA 94035, United States
[c] Johns Hopkins University Applied Physics Laboratory, Laurel, MD 20723, United States
[d] NOAO, P.O. Box 26732, Tucson, AZ 85726, United States
[e] Southwest Research Institute, 1050 Walnut St. Suite 300, Boulder, CO 80302, United States
[f] Planetary Science Institute, 1700 E Fort Lowell Suite 106, Tucson, AZ 85719, United States
[g] Department of Earth and Planetary Sciences, Washington University, St. Louis, MO 63130, United States



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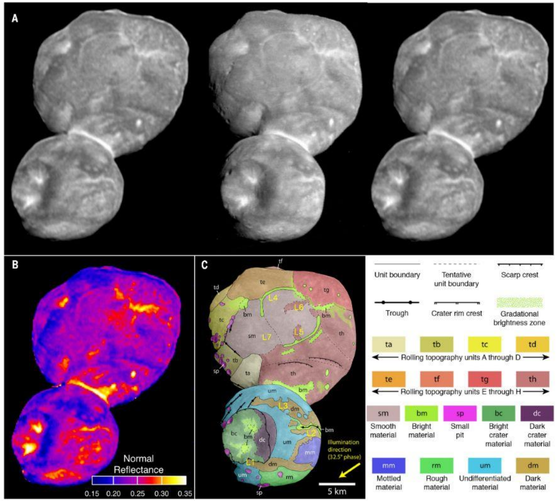
Topography studies from literature

- Pluto system (Moore et al. 2016; Nimmo et al. 2017);
- Arrokoth (Spencer et al. 2020);



RESEARCH

RESEARCH ARTICLE

OUTER SOLAR SYSTEM

The geology and geophysics of Kuiper Belt object (486958) Arrokoth

J. R. Spencer[1]*, S. A. Stern[1], J. M. Moore[2], H. A. Weaver[3], K. N. Singer[1], C. B Olkin[1], A. J. Verbiscer[4], W. B. McKinnon[5], J. Wm. Parker[1], R. A. Beyer[6,2], J. T. Keane[7], T. R. Lauer[8], S. B. Porter[1], O. L. White[6,2], B. J. Buratti[9], M. R. El-Maarry[10,11], C. M. Lisse[3], A. H. Parker[1], H. B. Throop[12], S. J. Robbins[1], O. M. Umurhan[2], R. P. Binzel[13], D. T. Britt[14], M. W. Buie[1], A. F. Cheng[3], D. P. Cruikshank[2], H. A. Elliott[15], G. R. Gladstone[15], W. M. Grundy[16,17], M. E. Hill[3], M. Horanyi[18], D. E. Jennings[19], J. J. Kavelaars[20], I. R. Linscott[21], D. J. McComas[22], R. L. McNutt Jr.[3], S. Protopapa[1], D. C. Reuter[19], P. M. Schenk[23], M. R. Showalter[6], L. A. Young[1], A. M. Zangari[1], A. Y. Abedin[20], C. B. Beddingfield[6], S. D. Benecchi[24], E. Bernardoni[18], C. J. Bierson[25], D. Borncamp[26], V. J. Bray[27], A. L. Chaikin[28], R. D. Dhingra[29], C. Fuentes[30], T. Fuse[31], P. L Gay[24], S. D. J. Gwyn[20], D. P. Hamilton[32], J. D. Hofgartner[9], M. J. Holman[33], A. D. Howard[34], C. J. A. Howett[1], H. Karoji[35], D. E. Kaufmann[1], M. Kinczyk[36], B. H. May[37], M. Mountain[38], M. Pätzold[39], J. M. Petit[40], M. R. Piquette[18], I. N. Reid[41], H. J. Reitsema[42], K. D. Runyon[3], S. S. Sheppard[43], J. A. Stansberry[41], T. Stryk[44], P. Tanga[45], D. J. Tholen[46], D. E. Trilling[17], L. H. Wasserman[16]

The Cold Classical Kuiper Belt, a class of small bodies in undisturbed orbits beyond Neptune, is composed of primitive objects preserving information about Solar System formation. In January 2019, the New Horizons spacecraft flew past one of these objects, the 36-kilometer-long contact binary (486958) Arrokoth (provisional designation 2014 MU_{69}). Images from the flyby show that Arrokoth has no detectable rings, and no satellites (larger than 180 meters in diameter) within a radius of 8000 kilometers. Arrokoth has a lightly cratered, smooth surface with complex geological features, unlike those on previously visited Solar System bodies. The density of impact craters indicates the surface dates from the formation of the Solar System. The two lobes of the contact binary have closely aligned poles and equators, constraining their accretion mechanism.

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Topography studies from literature

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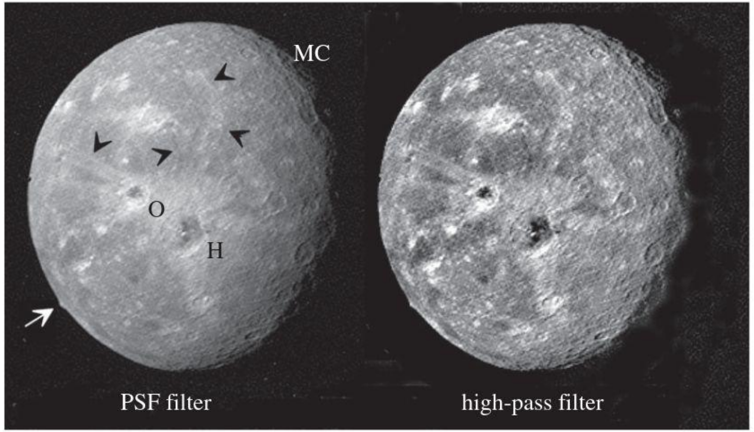
- Arrokoth (Spencer et al. 2020);
- Uranus' satellites (Schenk & Moore, 2020);



Oberon

Topography and geology of Uranian mid-sized icy satellites in comparison with Saturnian and Plutonian satellites

Paul M. Schenk[1] and Jeffrey M. Moore[2]

[1]Lunar and Planteray Institute/USRA, Houston, TX, USA
[2]NASA Ames Research Center, Moffett Field, CA, USA

PMS, 0000-0003-1316-5667

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Topography supported on surface

ICARUS 18, 612–620 (1973)

Topography on Satellite Surfaces and the Shape of Asteroids[1]

T. V. JOHNSON[2] AND T. R. McGETCHIN

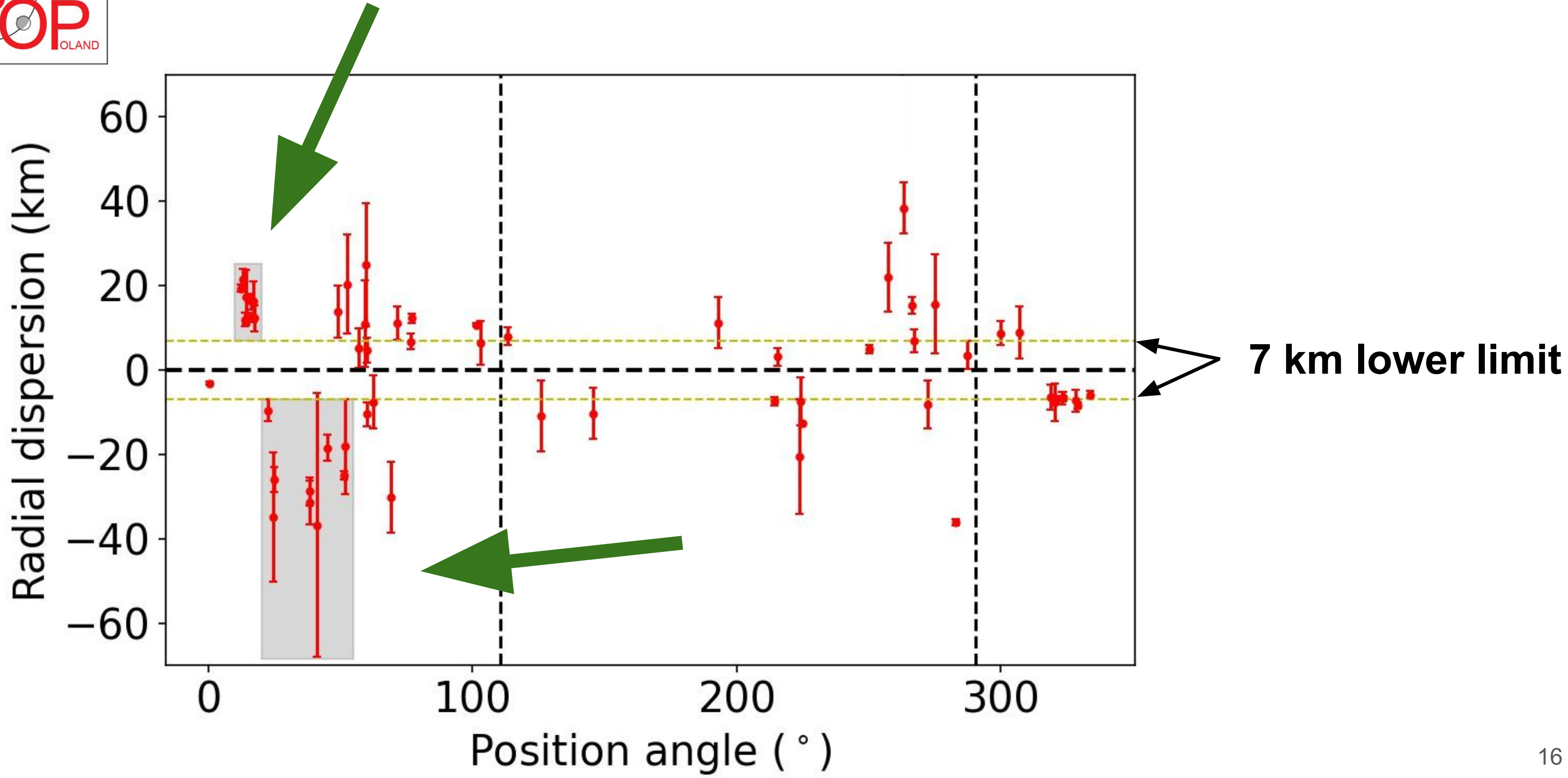
Department of Earth and Planetary Sciences,
Massachusetts Institute of Technology,
Cambridge, Massachusetts 02139

(Received August 27, 1972; revised November 9, 1972)

Calculations of the topography and shape of planetary bodies are presented for two sets of models. One set of models deals with the effects of static loading

Assuming:

- Mainly composed by Ice with strength = 0.0303×10^{9} Dyn/cm^2;
- ρ = 1.0−2.0 g/cm^3;
- Procedure from the paper;
- Theoretical lower limit is 6-7 km;
- Can support 20 km structures;



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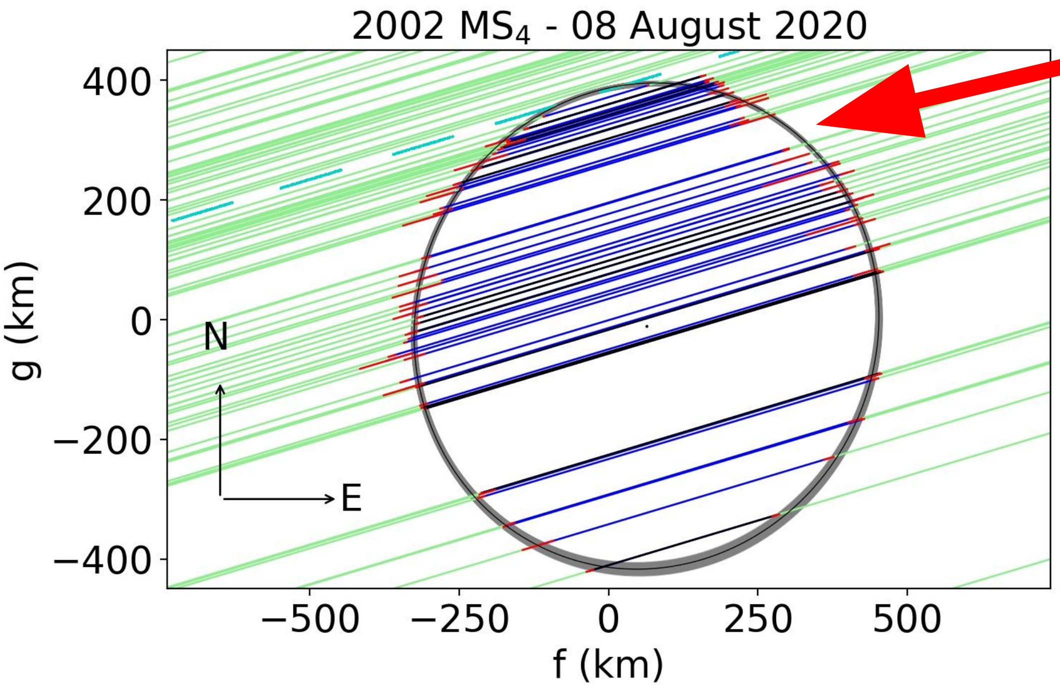
Topography



Most successful campaign of a stellar occultation by a TNO.

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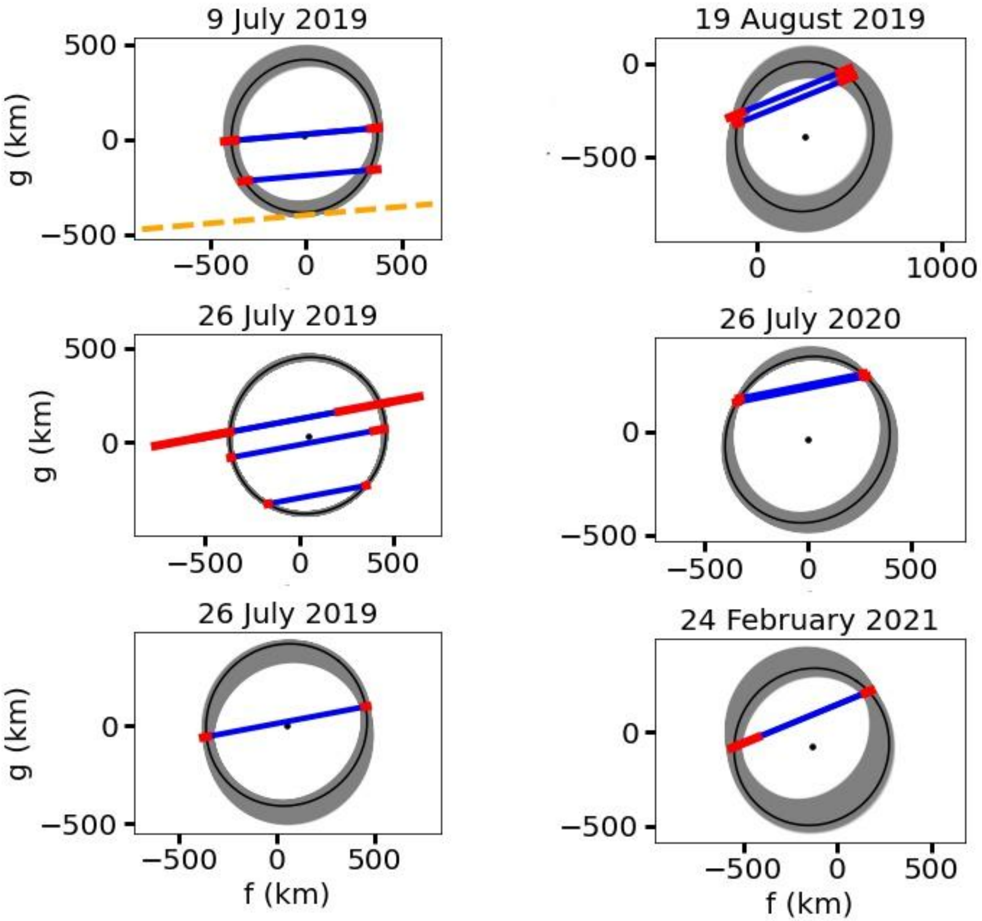
Other 6 occultations

Same ellipse parameters:

- Positives (blue) + uncertainties (red);
- Close negative (orange);
- Best fit (black ellipse);
- 1σ solutions (grey);
- Center (black dot).



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Final considerations

- Paper is being written with this results;
- Future works involve:
  - Photometric observations to derive rotational light curve;
  - Imaging differencing analysis;
  - Scan stellar occultation light curves to determine upper limits for the presence of surrounding material or atmosphere.

Flavia L. Rommel (flaviarommel@on.br)

Thank you for your attention and collaboration!

Flavia L. Rommel (flaviarommel@on.br)