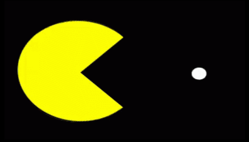
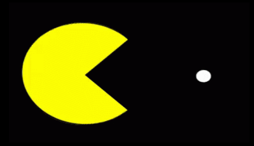
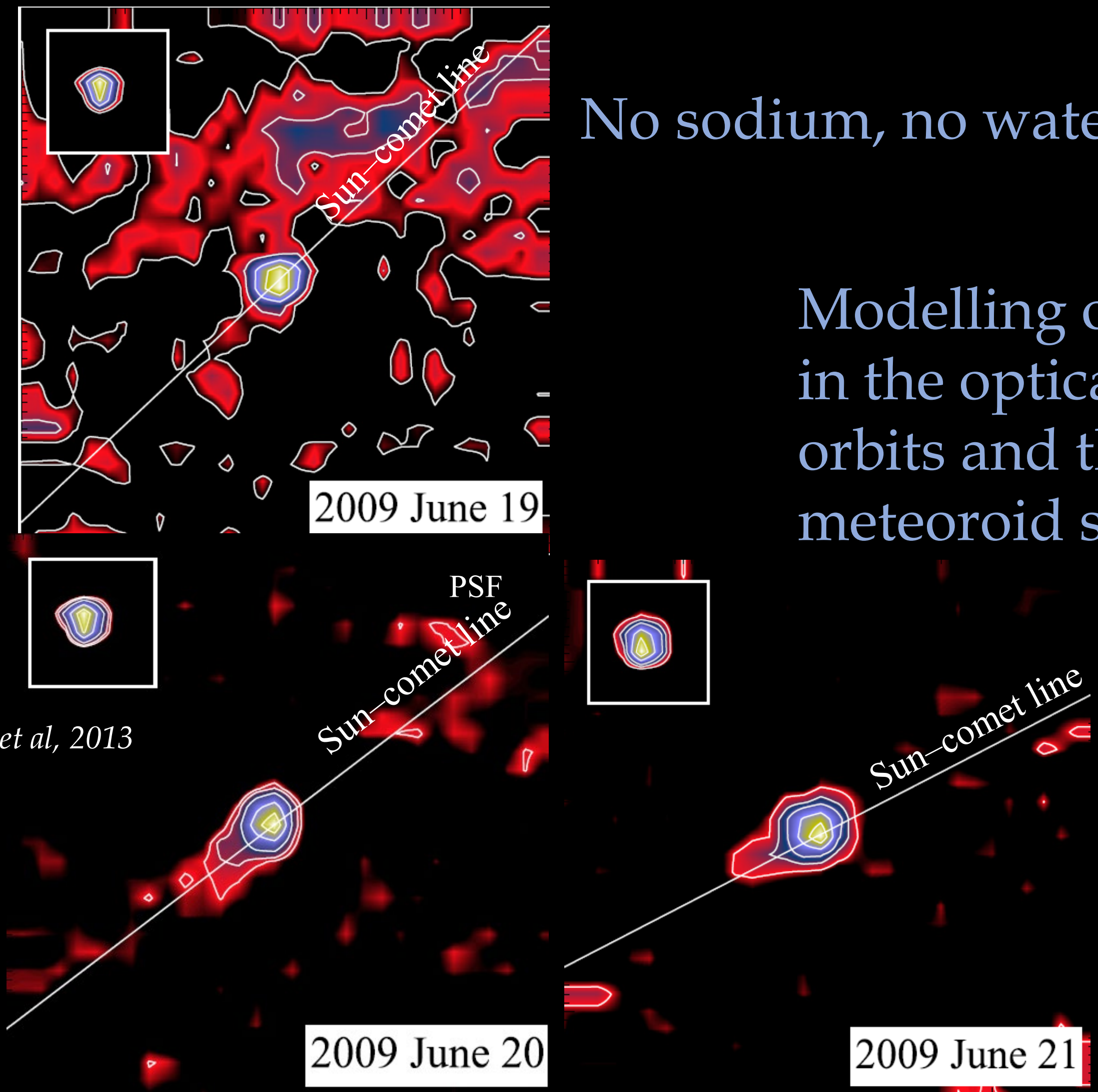
PA MAN





- Discovered in 1983 it is an Apollo near-Earth asteroid (NEA) of about 6 km diameter
- It has a peculiar orbit: high inclination =22° very low perihelion distance = 0.14 AU
- Tisserand parameter suggested it is an asteroid Tj =4.2 whereas for comets is Tj<3 (superior limit for Jupiters)
- Dynamically associated with the Geminid meteor stream (e.g. Gustafson 1989; Jenniskens 2006)
- Originated in the n6 resonance of the Main Belt (Bottke 2002)
- As asteroid is linked as a B type asteroid linked to Pallas and Pallas family (De Leon et al., 2009)

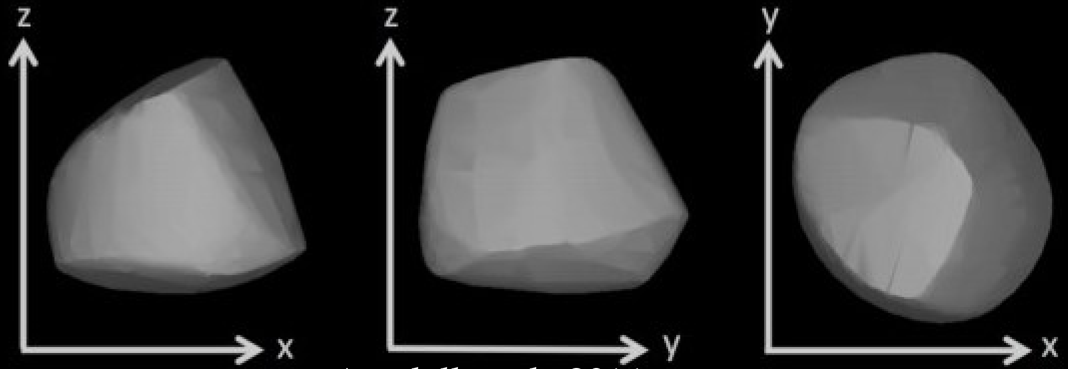


Jewitt et al, 2013

No sodium, no water related by-products …it is a dust tail

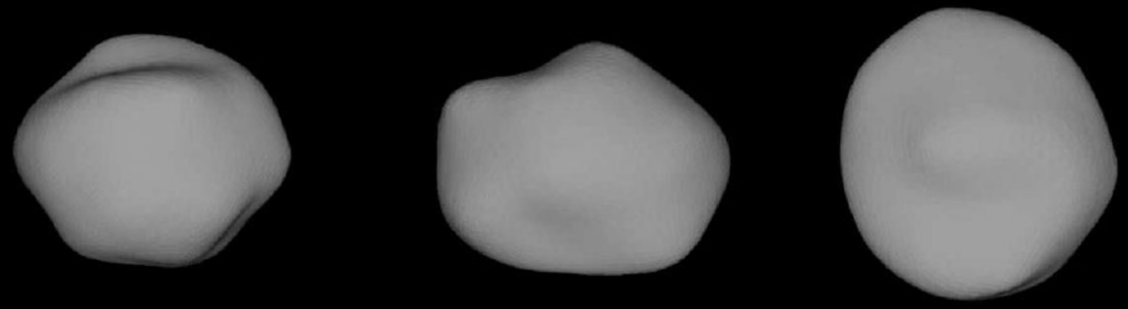
Modelling of dust ejection shows that most particles in the optical tail follow gravitationally unbound orbits and thus do not contribute to the Geminid meteoroid stream.…

Previously suggested mechanisms of thermal fracture and desiccation cracking of hydrated minerals remain plausible sources of Phaethon’s tail.

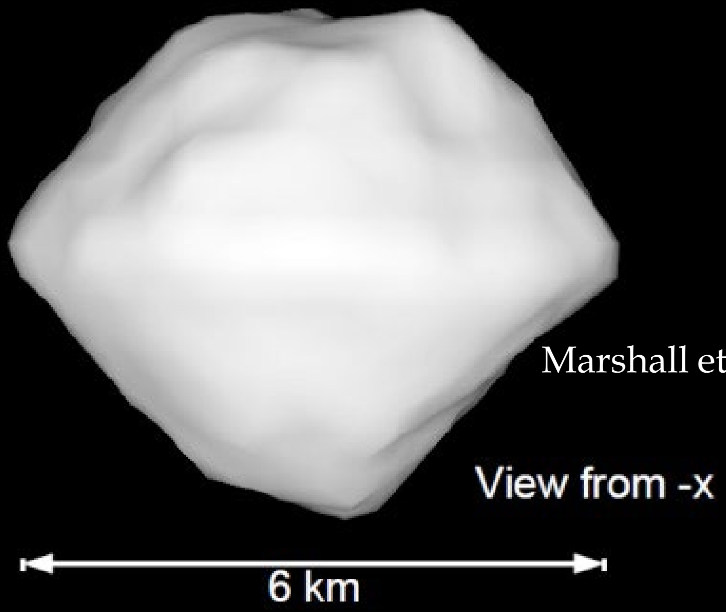


Ansdell et al., 2014

Kim et al. 2019



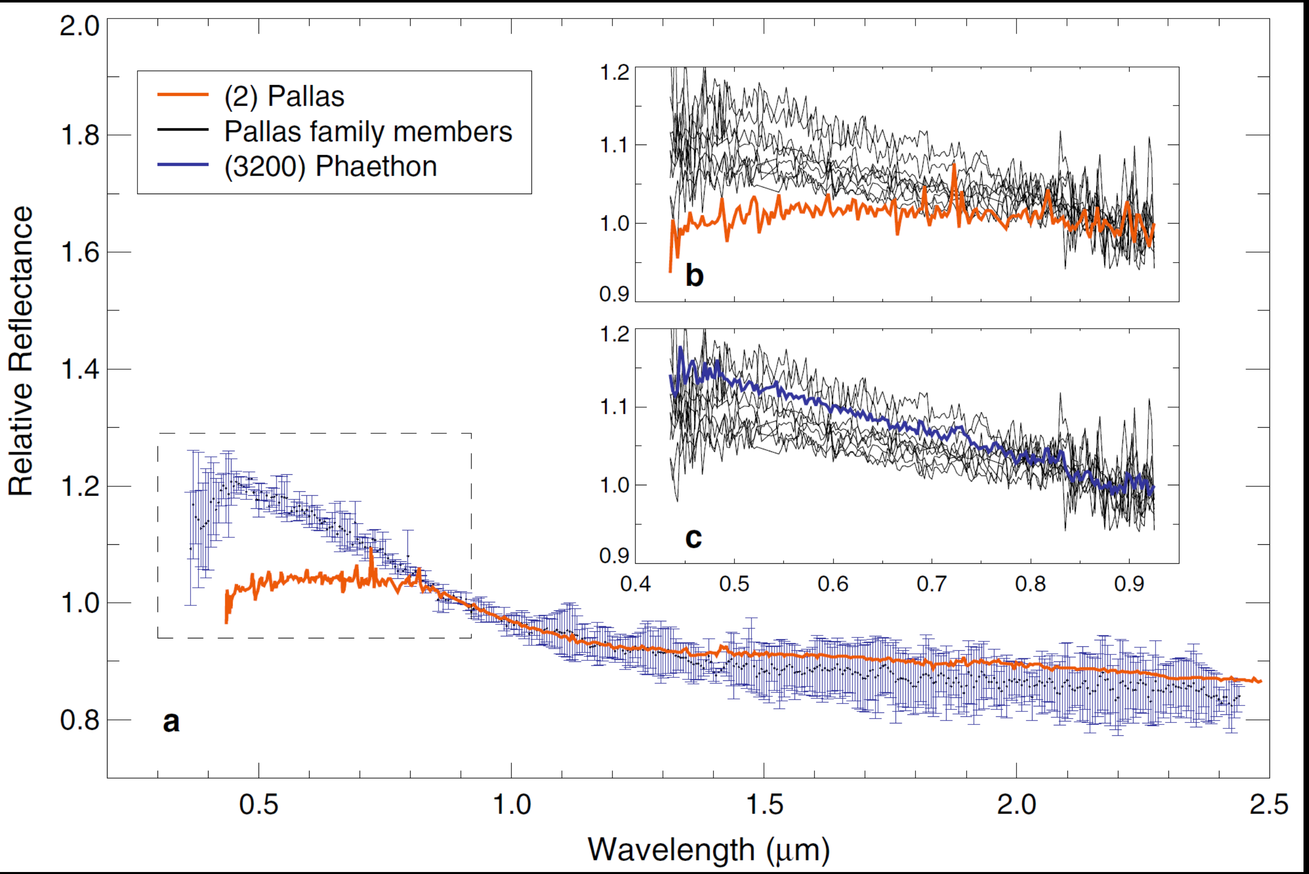
x-axis (Aspect = 90 °) y-axis (Aspect = 90 °) z-axis (Aspect = 0 °)



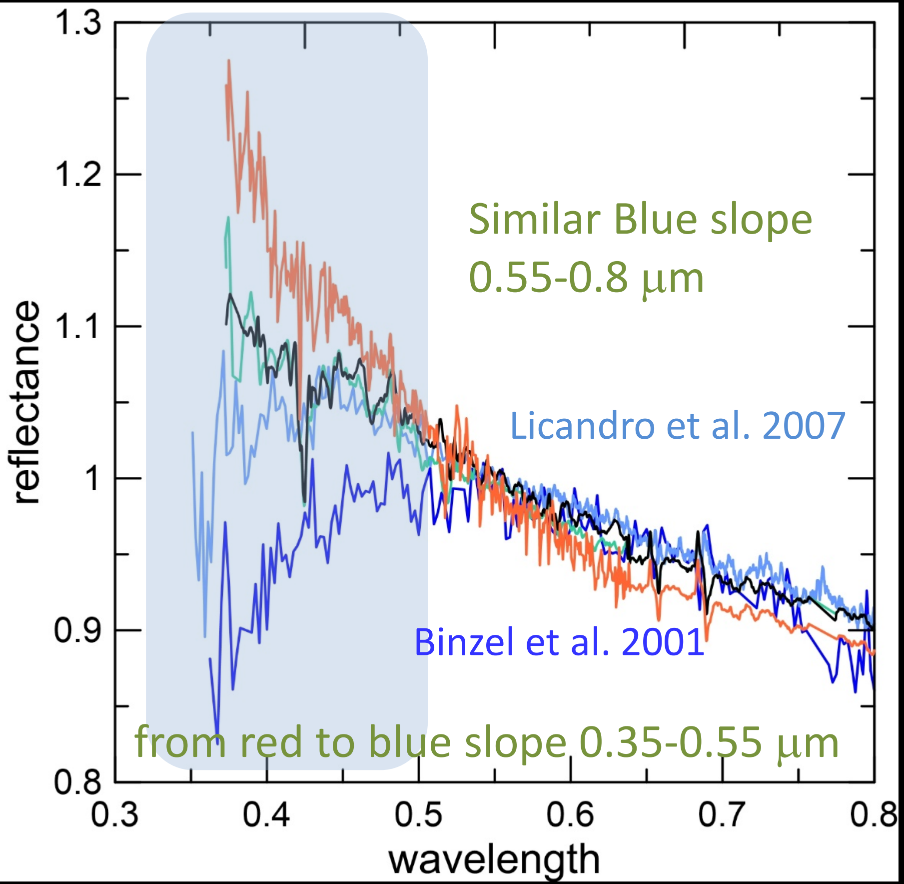
Marshall et al. 2019

Taylor et al., 2018

- In the Vis Phaethon and six Pallas family members spectra are identical but they differ from Pallas
- In the NIR Phaethon and Pallas are very similar, however, Pallas is hydrated Phaethon is not!!
- Strong differences in the UV drop-off spectral interval: Surface heterogeneities?



TNG Vis spectra



The PACMAN project has been selected in the framework of the PRIN INAF 2019

The PACMAN main objectives are:

- Understand the composition of the asteroid 3200 Phaethon
- Analyse which processes govern the transformation of its surface during the perihelion passages and the mechanisms responsible for dust ejection, possibly originating the Geminid meteoroids.
- Study the links between meteor showers and delivering of volatiles on Earth by using the Phaethon unique case, this is fundamental to understand weight of cosmic dust to the development of terrestrial life on the primordial Earth.

INAF-IAPS
(Istituto di Astrofisica e Planetologia Spaziali)

University of Firenze

INAF- OAC
(Osservatorio Astronomico di Capodimonte)

Observations and Laboratory experiments

Meteorites and mineralogy

Laboratory experiments

7 FTE total for 2 years of activity 105 k€ of budget
Expecting for ASI-INAF support for the participation to DESTINY+ space mission and progressing the current activity

KEY QUESTIONS	SCIENCE OBJECTIVES
Which are the mechanisms responsible for dust ejection from Phaethon? Phaeton should have lost most of volatiles, including hydrated materials as a result of extensive solar heating up to 1000K. It has been suggested that desiccation of hydrous minerals and thermal cracking on the surface of Phaethon be likely, but has not yet been demonstrated experimentally	• Select and procure a set of terrestrial (minerals) and extraterrestrial (meteorites) samples in order to create the best analogue of the Phaethon surface in laboratory; • Create dedicated experiments to properly simulate the very harsh interplanetary environment encountered by the asteroid; • Characterize the mineralogical/morphological transformation occurring on analogue during and after heating (simulating Phaethon perihelion passages)
There is a great variability in the Phaethon spectra: Strong surface heterogeneity? None of known meteorite types are matched with the blue spectra of Phaethon, while multiple candidates have been suggested, such as aqueously and/or thermally altered carbonaceous chondrites.	• Spectral comparison of laboratory processed analogues with observational data

Lazzarin et al. 2019

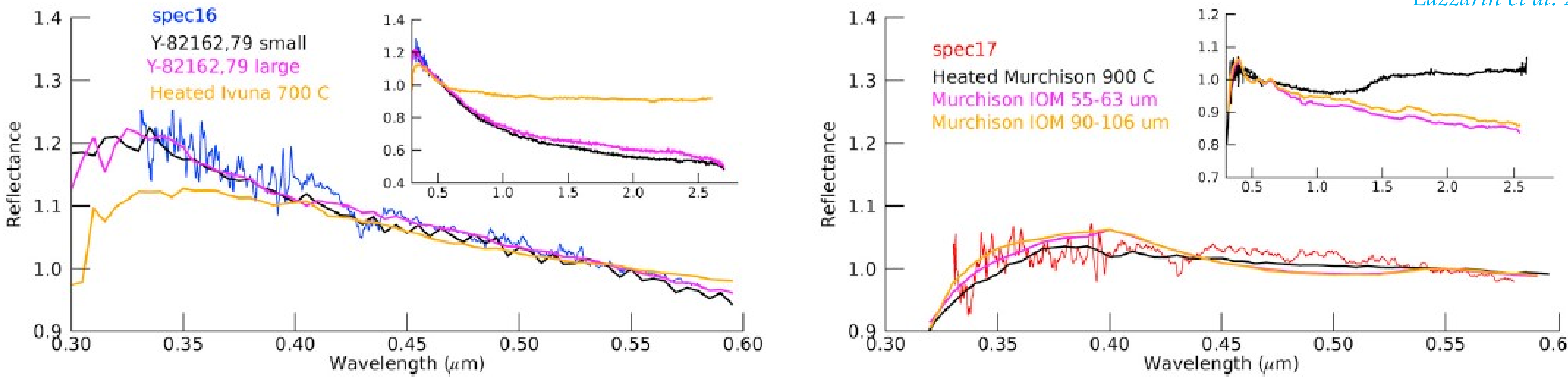
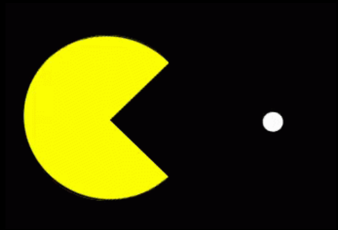


Fig. 4. Comparison of Phaethon optical spectra (left: spectrum observed on 16 December 2017; right: spectrum observed on 17 December 2017) with meteoritic analogs form RELAB database. Large plots show the range [0.33–0.58] μm of our optical spectra, and small inner plots show the whole VIS-NIR wavelength range.

- Phaethon's spectra show similarities with thermally heated hydrated minerals, mixed with dark compounds and to carbonaceous chondrite (CC) meteorites that experienced aqueous alteration and subsequent heating.
- It seems that the best analogues are represented by mixtures of: dehydroxylated phyllosilicates and dark compounds (typically oxides such as magnetite or carbon rich material) often occurring in carbonaceous chondrites (CCs).
- Procurement, characterization of Carbonaceous Chondrites (i.e. Tagish Lake) and terrestrial minerals will be performed in the first part of the project



Important action of this task is the assessment of scientific and technological requirements to reproduce 3200 Phaethon in laboratory:

- Understanding the grain size of grains composing the regolith;
- Better comprehension of the thermal behaviour of Phaethon’s surface when crossing the perihelion;

SECOND OBJECTIVE:

Simulating Phaethon regolith processing

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King et al. 2021

Phaethon has high degree of linear

Polarization and this suggests

Large porosity

Large grain size 300 μm

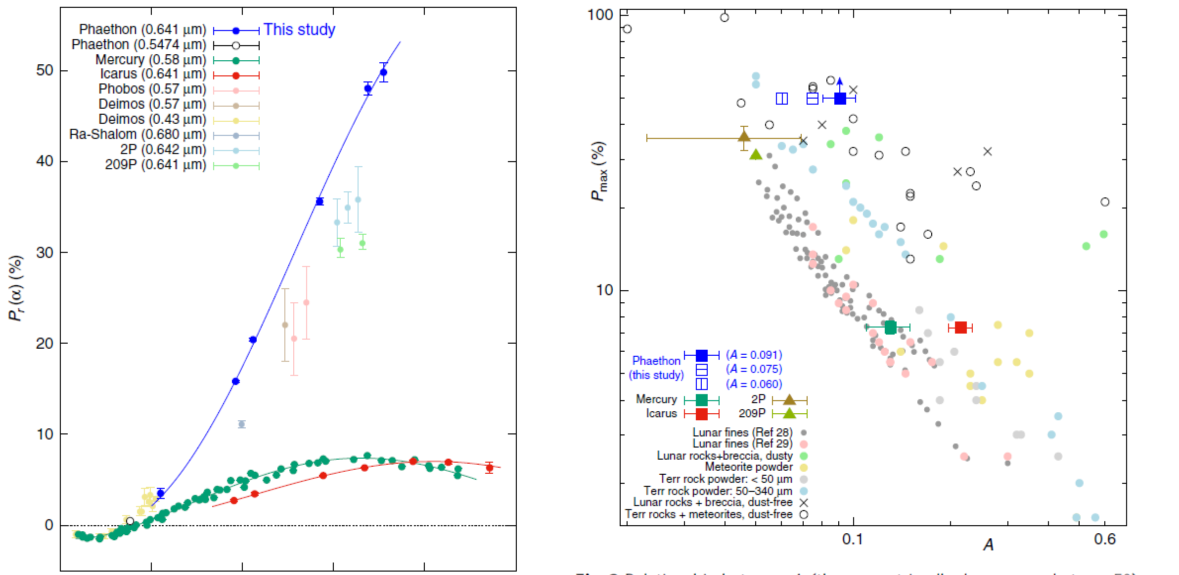

Fig. 2 Relationship between A (the geometric albedo measured at $\alpha = 5°$) and P_{max} for Phaethon and other objects. In this figure, Phaethon is

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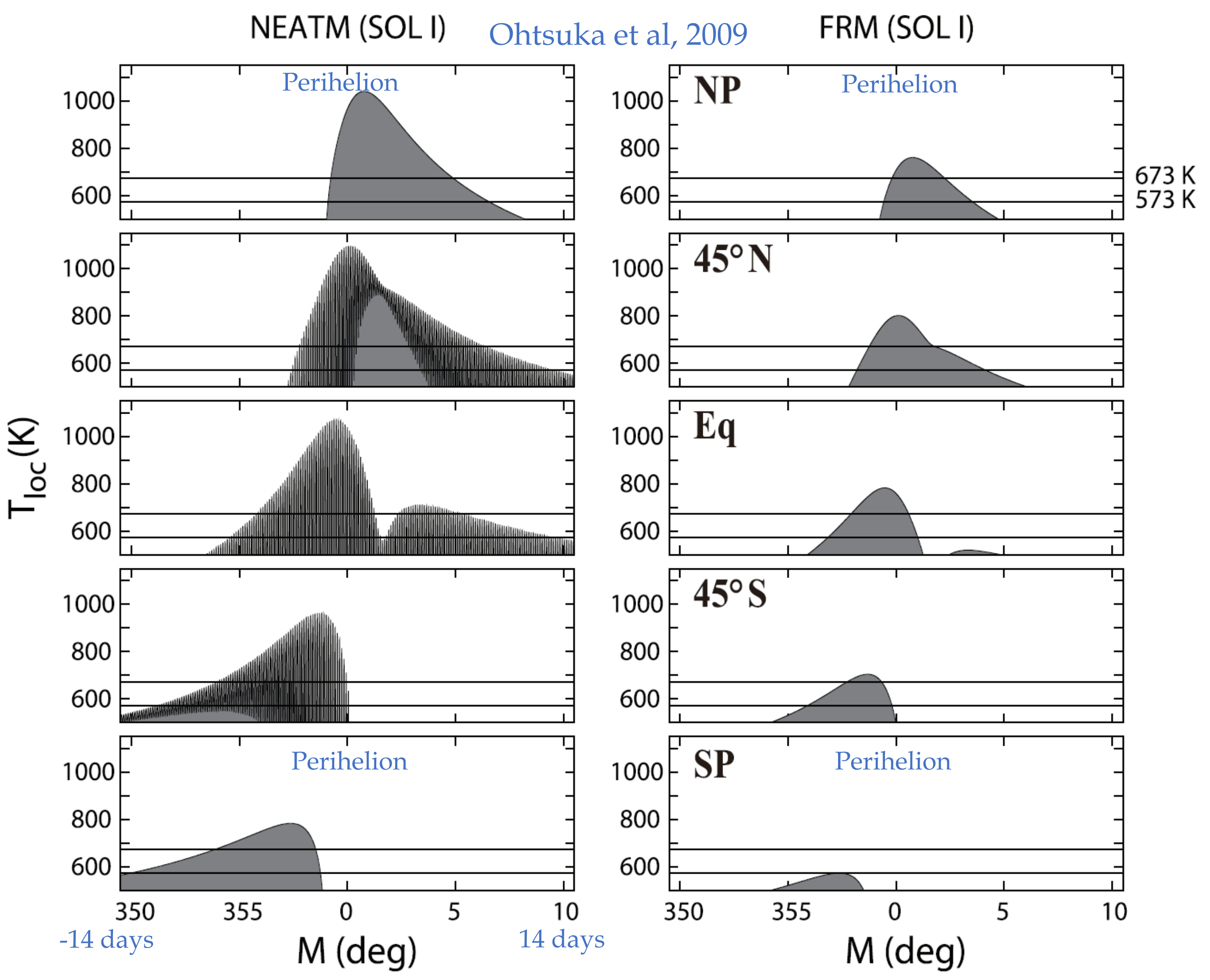
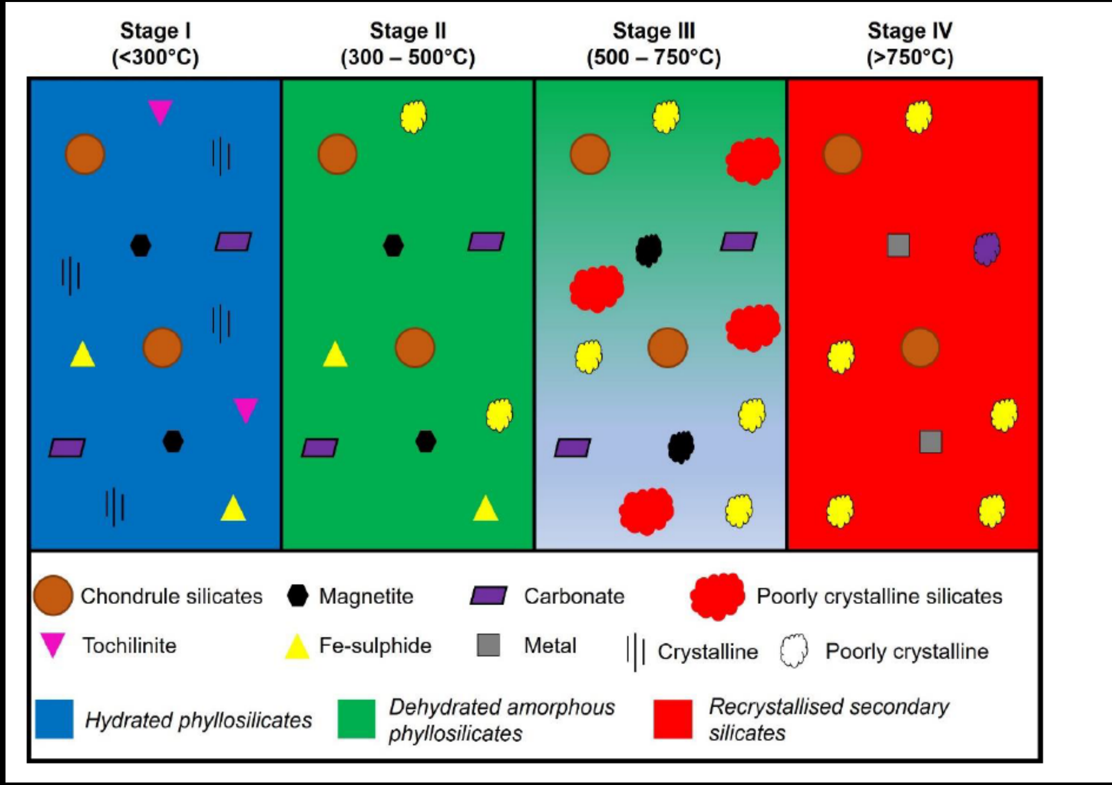
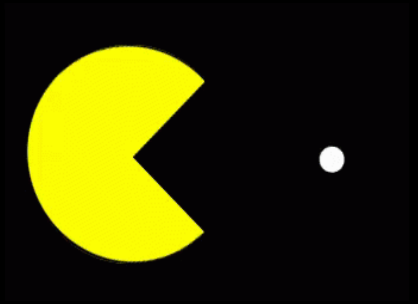




King et al. 2021



- Size calibrated samples in intervals from 1 up to 500 µm (e.g 20-50 µm 50-100 µm, 100-200 µm, etc.) will be produced in laboratory by using an automatic sieving system.

- The reflectance spectra of end-members, mixtures and CCs will be acquired in the UV-VIS interval (0.2-1 µm) and IR (1-25 µm) spectral range.

- Definition of an experimental chain of analysis and processing of the asteroid analogues

Each sample will be divided in two parts (Sample 1 and Sample 2) with same morphological and mineralogical characteristics. The two samples will be processed with the same methodologies. Sample 1 will be measured for spectroscopic investigations and Sample 2 for mineralogical analysis .

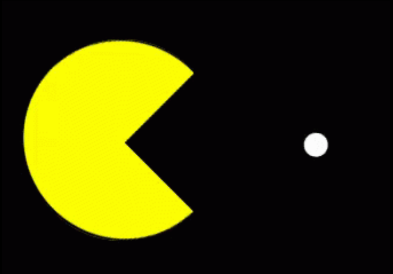
Samples
Create Phaethon analogues by using Carbonaceous Chondrites and terrestrial analogues, fragmentation and electronic sieving for calibrated size intervals

Mineralogical analysis
XRD diffractometry and Rietveld technique

Reflectance spectra
UV-Visible-Infrared diffuse reflectance analysis of the sample by means of spectrometers

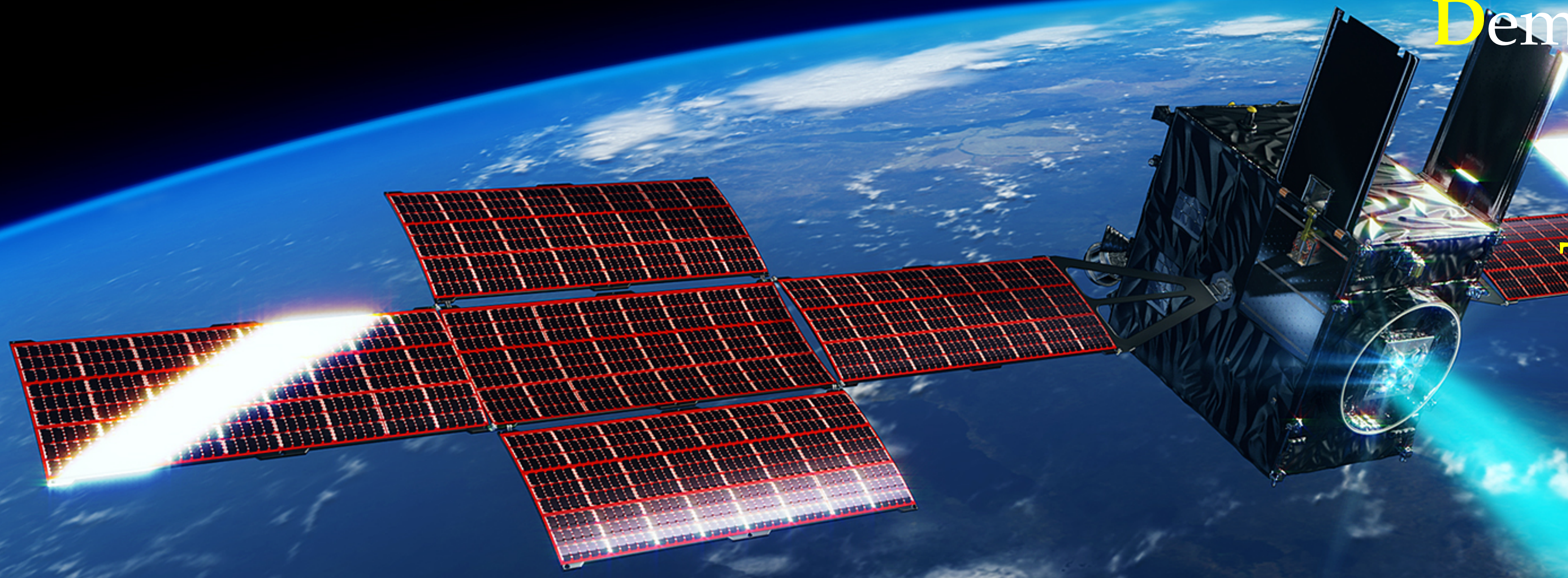
Thermal annealing
(from 300 to 1100 K)

Scanning Electron Microscope (SEM) analysis for morphological characterization



DATE OF OBSERVATION	TELESCOPE	SPECTRAL RANGE	REFERENCES
1994, Oct.11	3.6-m Canadian–French–Hawaiian telescope, Mauna Kea Observatory	0.38-1.0 µm	Lazzarin et al. 1996
1994, Dec. 18	K-band Spectrograph (KSPEC), Institute for Astronomy of the University of Hawaii	0.8-2.5 µm	Dumas et al. 1998
1998, Nov.13	Hubble Space Telescope's (HST) Near Infrared Camera and Multi Object Spectrometer (NICMOS)	0.9-2.5 µm	Campins et al. 1999
2003, Nov. 14	4.2 m William Herschell Telescope (WHT) Roque del Los Muchachos Observatory, La Palma	0.8-2.4 µm	Licandro et al. 2006
2004, Dec. 11	Telescopio Nazionale Galileo (TNG), Roque del Los Muchachos Observatory, La Palma	0.8-2.4 µm	Licandro et al. 2006
2004, Dec. 20	2.5 m Nordic Optical Telescope (NOT), Roque del Los Muchachos Observatory, La Palma	0.35-0.9 µm	Licandro et al. 2006
2005, Jan. 14	Spitzer (IRS instrument)	14.0-38 µm	McAdam et al. 2018
2007, Nov. 5	Tillinghast 1.5 m telescope on Mount Hopkins, Arizona	0.4-0.74 µm	Kareta et al. 2018
2007, Nov.30-Dec. 2	1-m telescope at Lulin observatory in Taiwan (LOT)	0.4-0.7 µm	Kinoshita et al. 2017
2017, Dec. 7	1.8 m telescope at Mt. Bohyunsan Optical Astronomy Observetory (BOAO)	0.4-0.7 µm	Lee et al. 2018
2017, Dec. 16	Telescopio Nazionale Galileo (TNG), Roque del Los Muchachos Observatory, La Palma	0.4-2.5 µm	Palomba et al. 2018
2017, Dec.12	NASA InfraRed Telescope Facility (IRTF), Mauna Kea Observatory, Hawaii	0.7-2.5 µm	Kareta et al. 2018
2017, Dec.16 17	1.22 m Galileo Telescope, Asiago	0.32-0.78 µm	Lazzarin et al. 2019

DESTIN



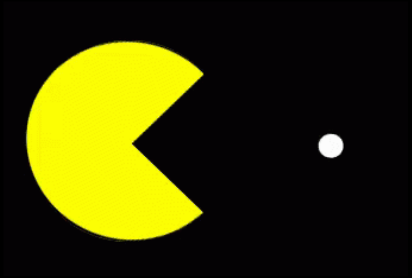
Demonstration and
Experiment
Space
Technology for
INterplanetary
VoYage

Phaethon
f**L**yby and
d**U**st **S**cience

Mission for JAXA/ISAS small-class program.

The launch is currently targeted in 2024.

It will conduct high-speed (33km/sec) flyby of asteroid (3200) Phaethon , which is a parent body of Geminid meteor shower



Spatial resolution of 5 and 10 m/pixel at a distance of 500 km and 1000 km, respectively

Detection of possible dust ejection features coming from its surface

Determination of Phaethon's light curve to estimate the rotational period

Characterize surface topography, define shape, and produce a 3D shape model

Telescopic CAmera for Phaeton (TCAP)

Images in the 400-950 nm spectral range by using 4 nominal bands (at 400, 550, 700 and 850 nm) and 2 optional bands (at 480 and 950 nm).

Spatial resolution of 100 m/pixel, enabling the observation of the surface and internal mineral distribution of the target

Multiband CAmera for Phaeton (MCAP)

Particle density

Particle composition (with a mass resolution $M/\Delta M$ larger than 150)

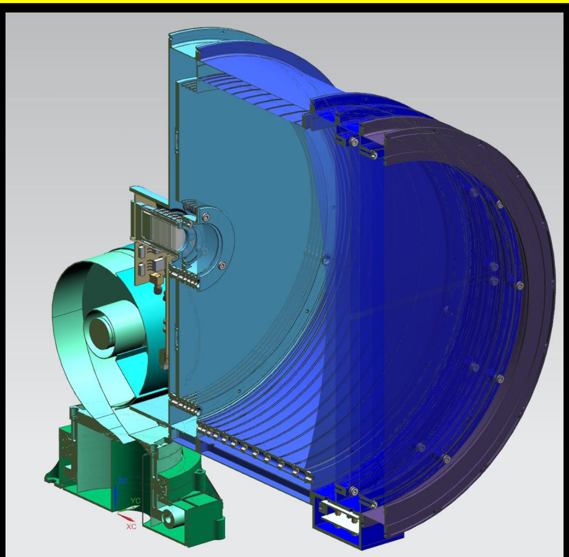
The electric charge (greater than 0.15 fC),

The mass (included between 10-16 and 10-6 g)

Speed (in the 5-100 km/s range)

Arrival direction of the smallest dust particles in a sensitive area of 0.011 m2

DESTINY+ Dust Analyzer (DDA)



SUMMARY

- The proposed research will try to suggest answers about the composition of Phaeton's regolith and the production of a dust tail in support of DESTINY +
- The heating procedure will be an important simulation of the evolution that the activated asteroid Phaethon experienced during the numerous passages at the perihelion, highlighting the alterations and dehydration processes of the surface
- PRIN-INAF financial support will cover 2 years but the participation to DESTINY+ will stimulate research activity up to the encounter with Phaethon 2028 (tbc)


GAME OVER
Press Space to Restart