Microreflectors for Asteroids and Comets: options for Hera

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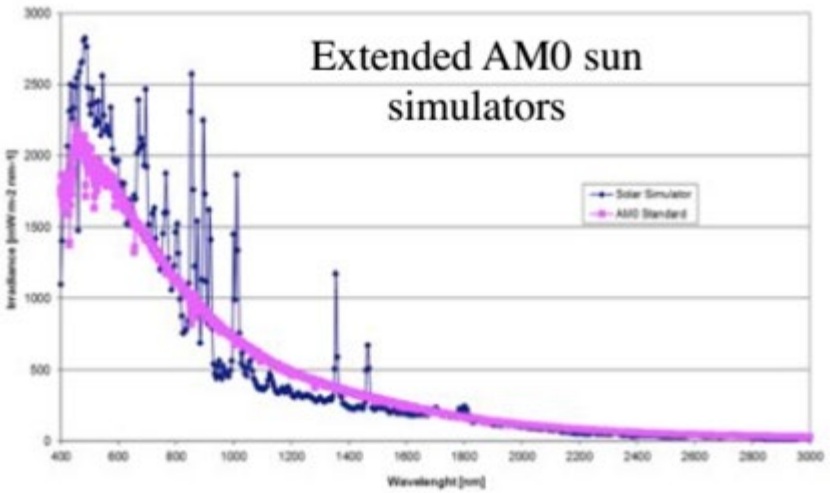
SCF_Lab
Satellite/Lunar/GNSS
laser ranging/altimetry and Cube/microsat
Characterization Facilities Laboratory

SCF_Lab (Satellite/lunar/GNSS laser ranging/altimetry and Cube/microsat Characterization Facilities Laboratory)

- Specialized Optical Ground Support Equipment
- Optical tests: Far Field Diffraction Pattern, Fizeau interferometry
- Representative space environments for TRL (**T**echnology **R**eadiness **L**evel) 6-7
- SCF (left) for laser ranging and altimetry & SCF-G (right) optimized for GNSS
- Two AM0 sun simulators, IR thermometry
- *J. Adv. Space Res. 47 (2011) 822–842*



Scientific activities @ the SCF_Lab

❑ Lunar Laser Ranging (LLR)

MoonLIGHT (**Moon** **L**aser **I**nstrumentation for **G**eneral relativity **H**igh-accuracy **T**ests).

❑ Satellite Laser Ranging (SLR)

Arrays of retroreflectors for: Galileo IOV (**I**n **O**rbit **V**alidation), IRNSS (**I**ndian **R**egional **N**avigation **S**atellite System), LAGEOS, GRA (**G**NSS **R**etroreflector **A**rray).

❑ Microreflector arrays in the Solar System

- On the Moon: INRRI (**IN**strument for landing-**R**oving laser **R**etroreflector **I**nvestigations), to be observed by laser equipped lunar orbiters**.**

- On Mars: INRRI on ExoMars 2016 (ESA), LaRRI (**La**ser **R**etro-**R**eflector for **I**nSight) on the InSight lander, landing on Mars on November 26, 2018 (NASA), LaRA (**La**ser **R**etro-reflector **A**rray) on Mars 2020 Rover (NASA).

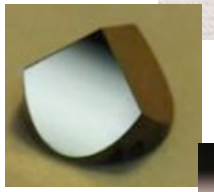
- On Asteroids and Comets: INRRI, LaRRI and LaRA on-board CubeSats or COSPHERA (**CO**met/asteroid **SPHE**rical **R**etroreflector **A**rray) landed/dropped on asteroid or comet to support laser tracking by orbiters, laser altimetry capabilities (like Hera), or lasercomm payloads.

INRRI, LaRRI & LaRA

- Microreflector array: 8 silver/Al coated 12.7mm retroreflectors (physical edges pointing to the center of a sphere), on a frame of aluminium alloy;
- Weight and size: 25 g for 5cm of radius and 2cm of height.

Goals

- Laser-location of lander/rovers on Moon/Mars/asteroids/comets from orbiters;
- Global and local networks for Exploration, Planetary Science,Geodesy and test Fundamental Gravity.



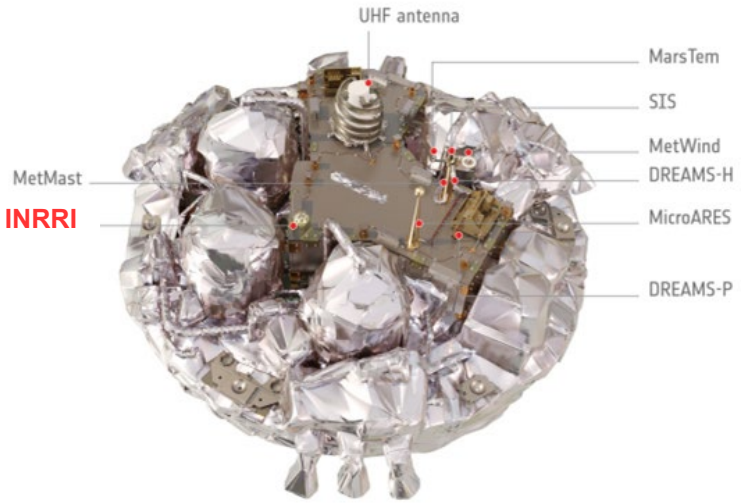
COSPHERA

- Microreflector array: 18 silver/Al coated 12.7mm retroreflectors with physical edges pointing toward the center of the spherical Aluminium frame.

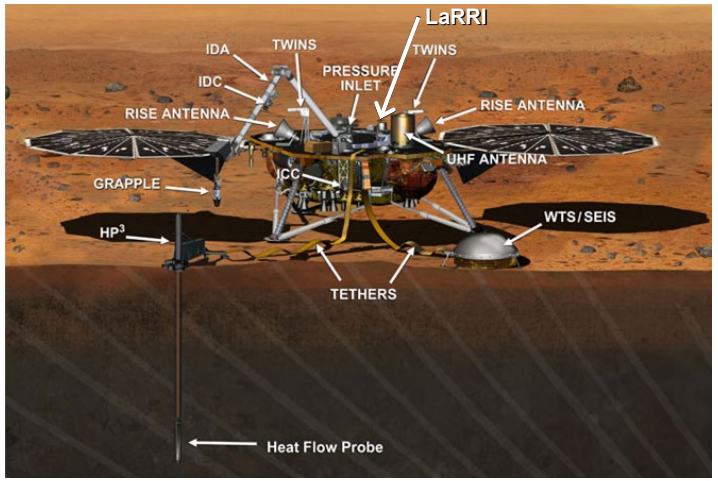
Goals

- To be dropped/landed on NEOs, in missions like the ESA candidate **Hera**.
- Supports laser ranging by orbiters, laser altimetry, or lasercomm payloads performing ToF(**T**ime-**o**f-**F**light) laser ranging (like OPTEL-D foreseen for Hera, formerly the **A**steroid **I**mpact **M**ission, AIM)

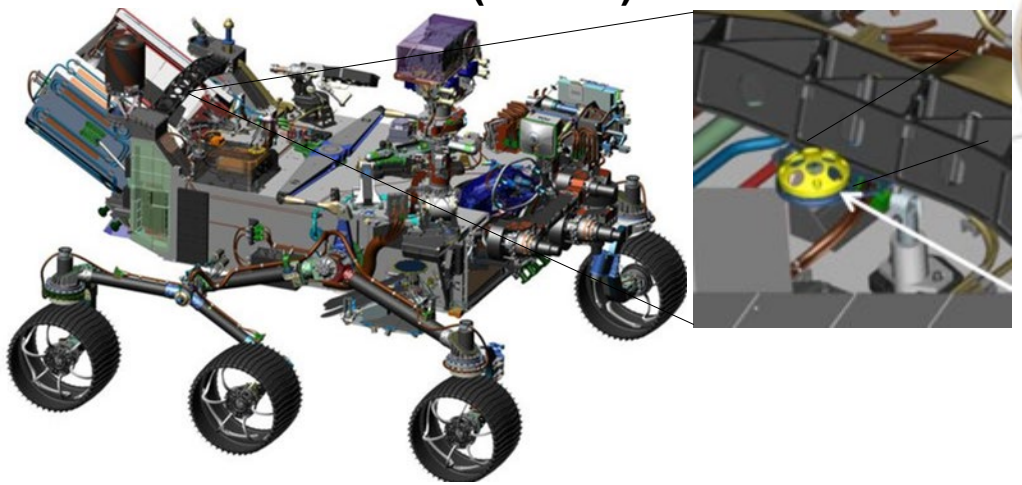
INRRI: the 1st μreflector on Mars on ExoMars 2016
(Dell'Agnello et al. 2017, Adv. Space Res. 59, 645)



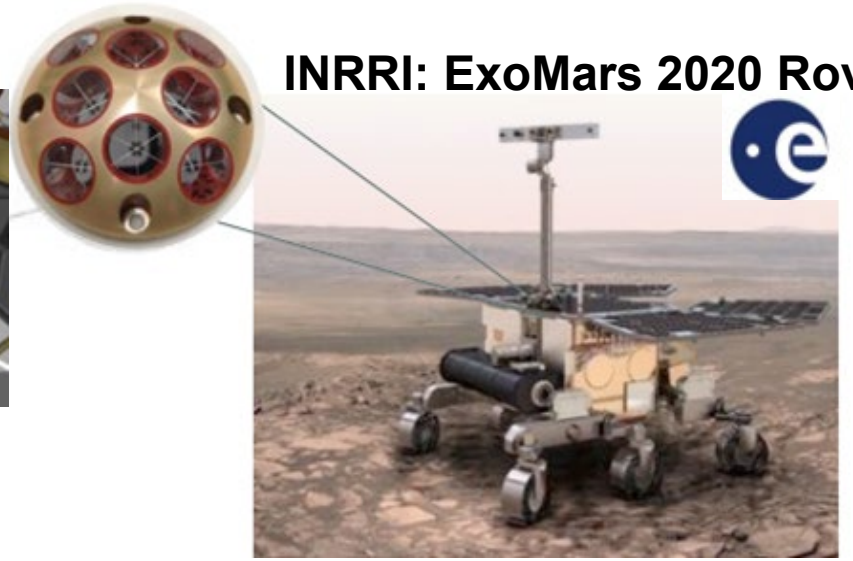
LaRRI: the 2nd μreflector on InSight Mars Lander
(Dell'Agnello et al. 2017, Space Res. Today 200)



LaRA: Mars 2020 Rover (NASA)



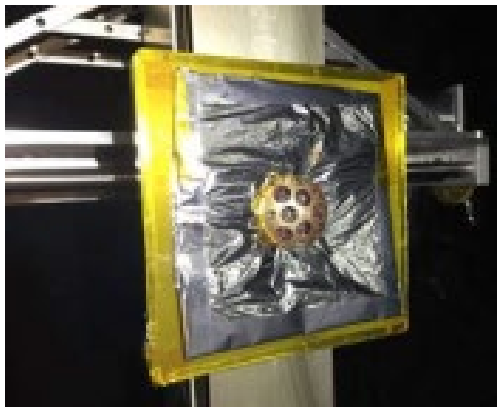
INRRI: ExoMars 2020 Rover (ESA)

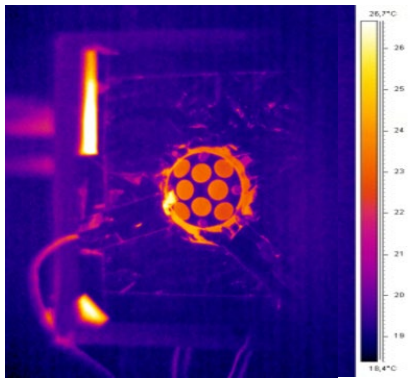


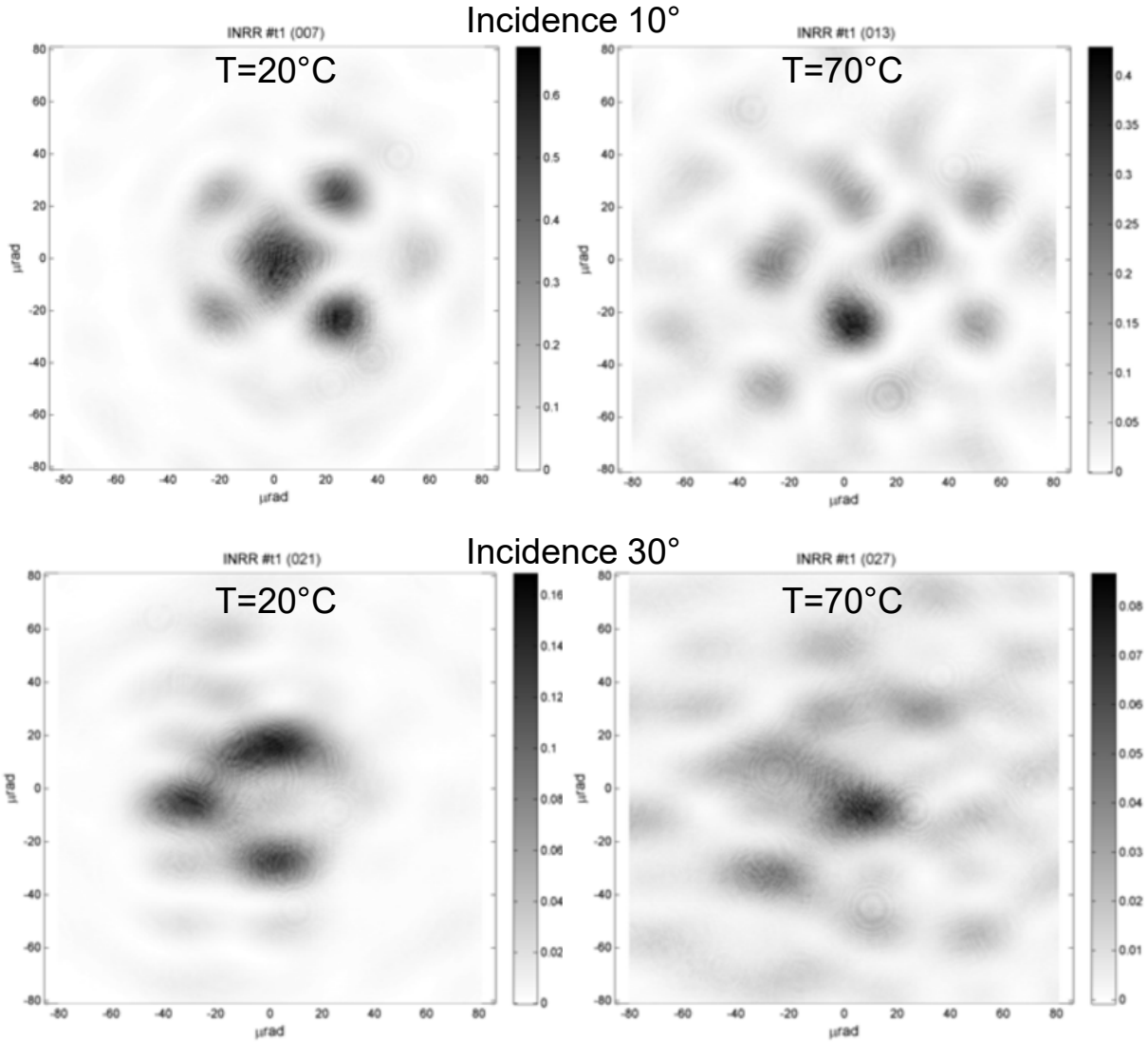
LaRRI optical performance test without Solar Simulator

In-air test in atmospheric/thermal conditions similar to those on Mars surface (except for dust storms).
LaRRI instrumented with heaters and temperature probes. Thermally decoupled through thermal blanket from an especially designed baseplate.
No vacuum was pulled.
– LaRRI bulk temperature: T=20–70°C in 10°C steps;
– Optical performances: θ=0°–30° laser incidence.

Without solar simulator, the array optical response at varying T and θ is preserved within factor ~2



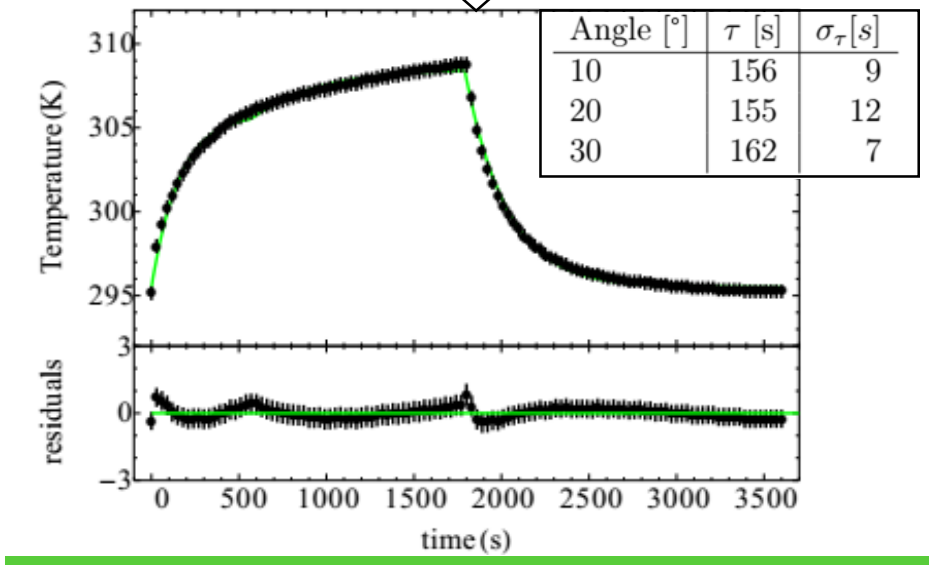




LaRRI optical performance test with the Solar Simulator

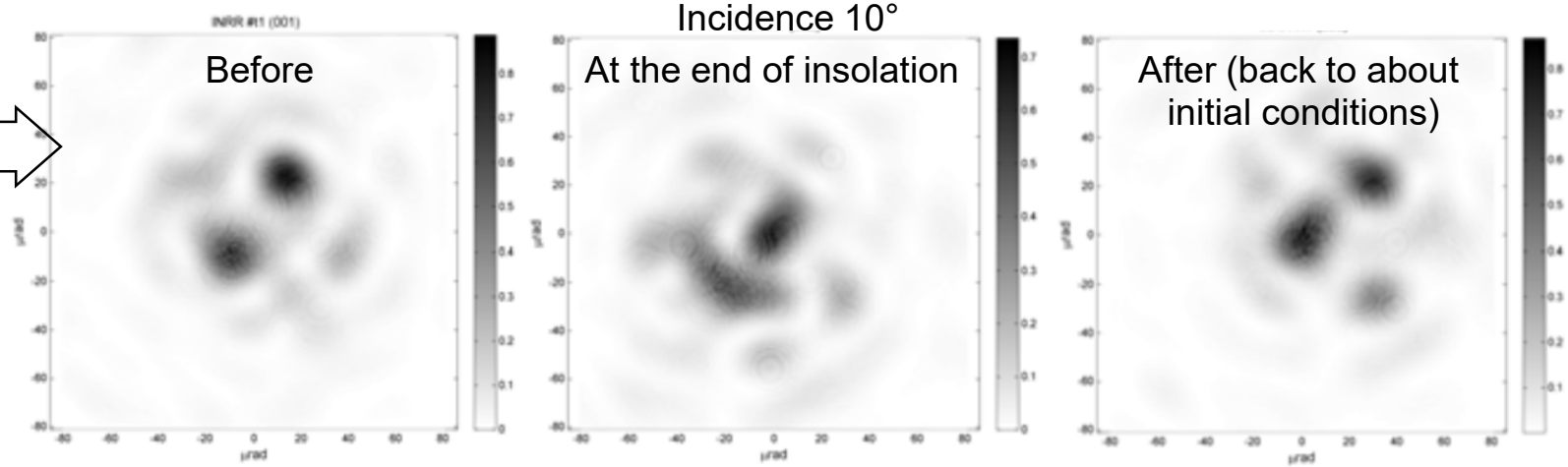
More realistic conditions with the solar simulator (Mars solar constant x2). **Varying shape of the array optical response. Intensity unchanged within a 20% level w.r.t. the nominal one.**

IR non-invasive measurements of T and thermal relaxation time τ

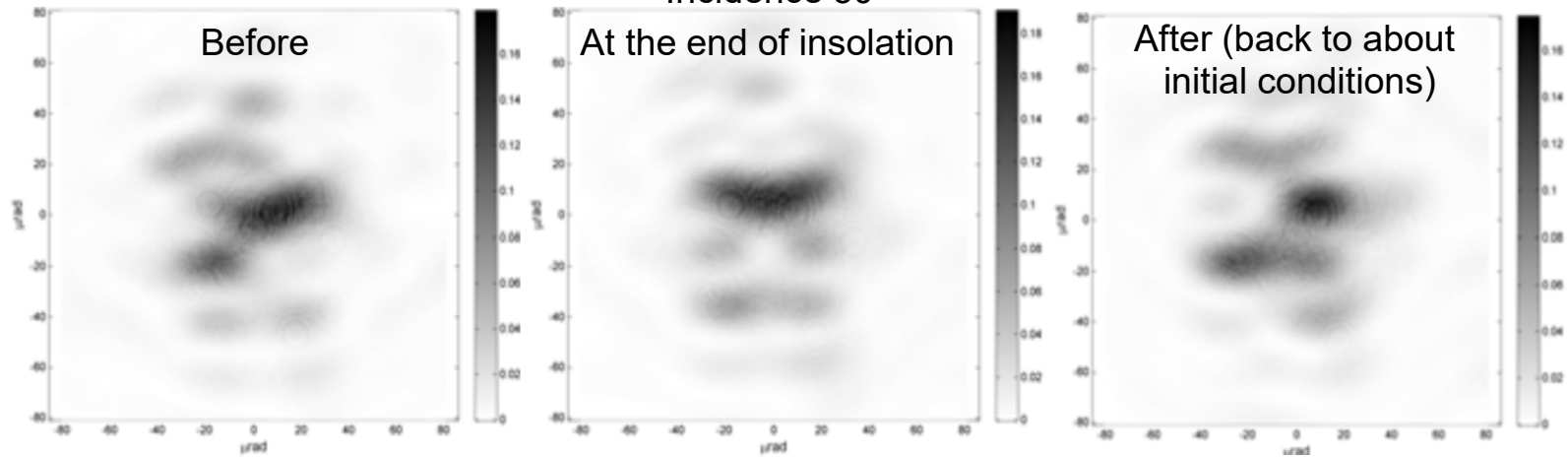


Angle [°]	τ [s]	σ_τ[s]
10	156	9
20	155	12
30	162	7

Incidence 10°



Incidence 30°

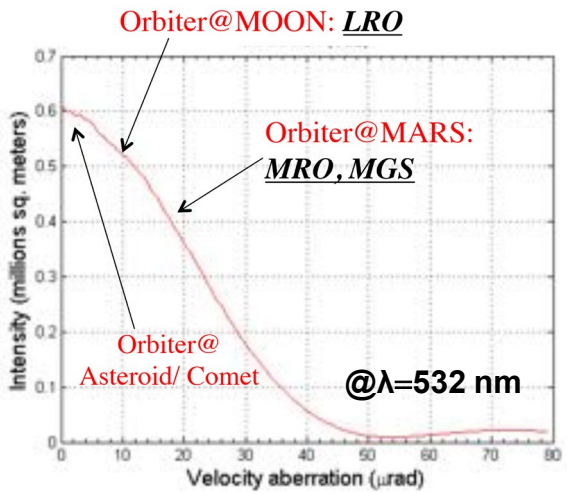


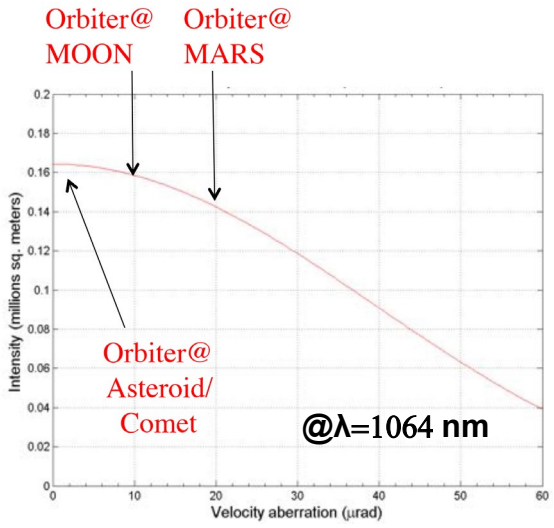
On asteroids and comets

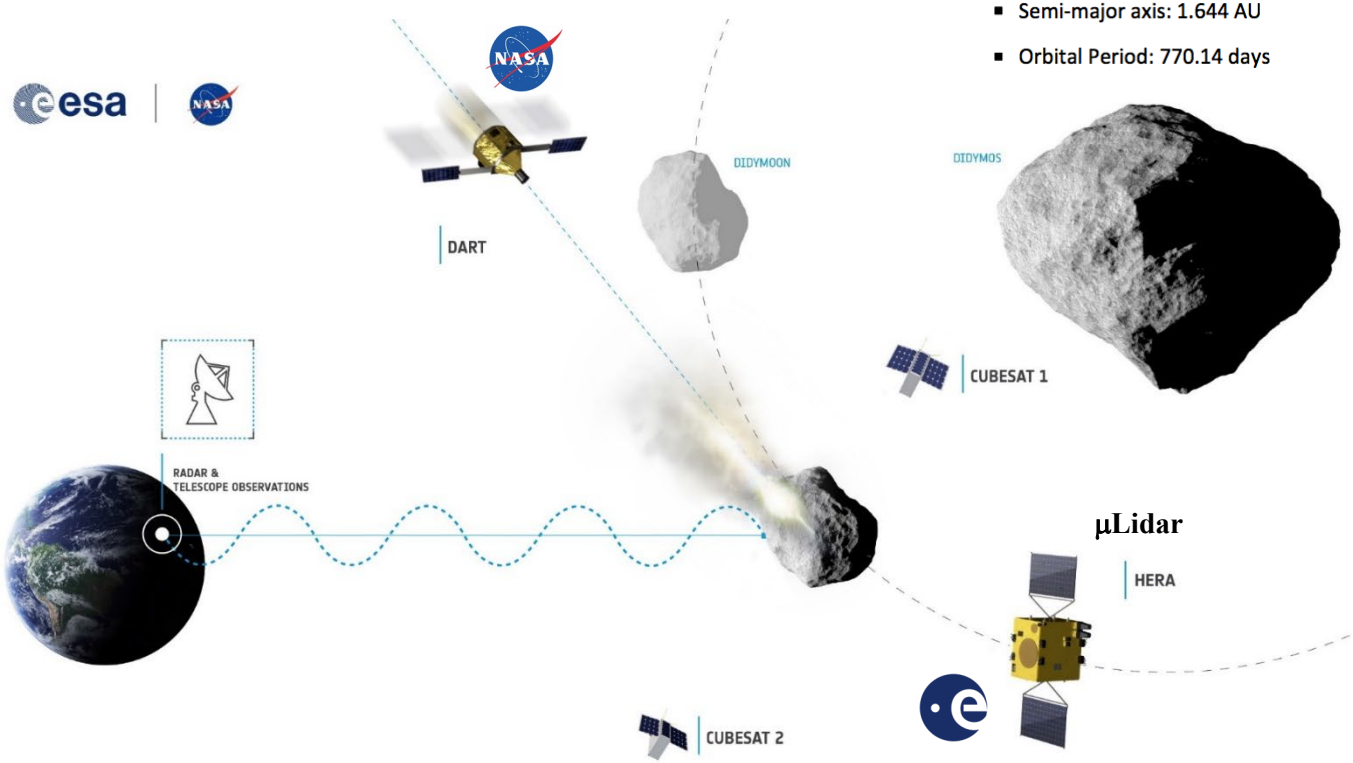
Hera will provide the first in-depth investigation of the binary near-Earth asteroid **(65803) Didymos** in 2026, four years after the impact of NASA's DART (**D**ouble **A**steroid **R**edirection **T**est) spacecraft [1].

- Eccentricity: 0.384
- Inclination: 3.4 deg
- Geometric albedo: 0.147
- Diameter primary: 800 m
- Diameter secondary: 170 m
- Separation: 1100 m
- Orbital period secondary: 11.9 h
- Semi-major axis: 1.644 AU
- Orbital Period: 770.14 days

Hera has on-board a μLidar that can perform ToF measurements [2] with our microreflectors:







[1] Michel et al. 2018, *Adv. in Space Res*. 62, 2261
[2] Carnelli, "The Hera Mission Study", ESA (2017). https://www.cosmos.esa.int/documents/336356/1503750/SMPAG09_HERA_Carnelli_2017-10-11.pdf.

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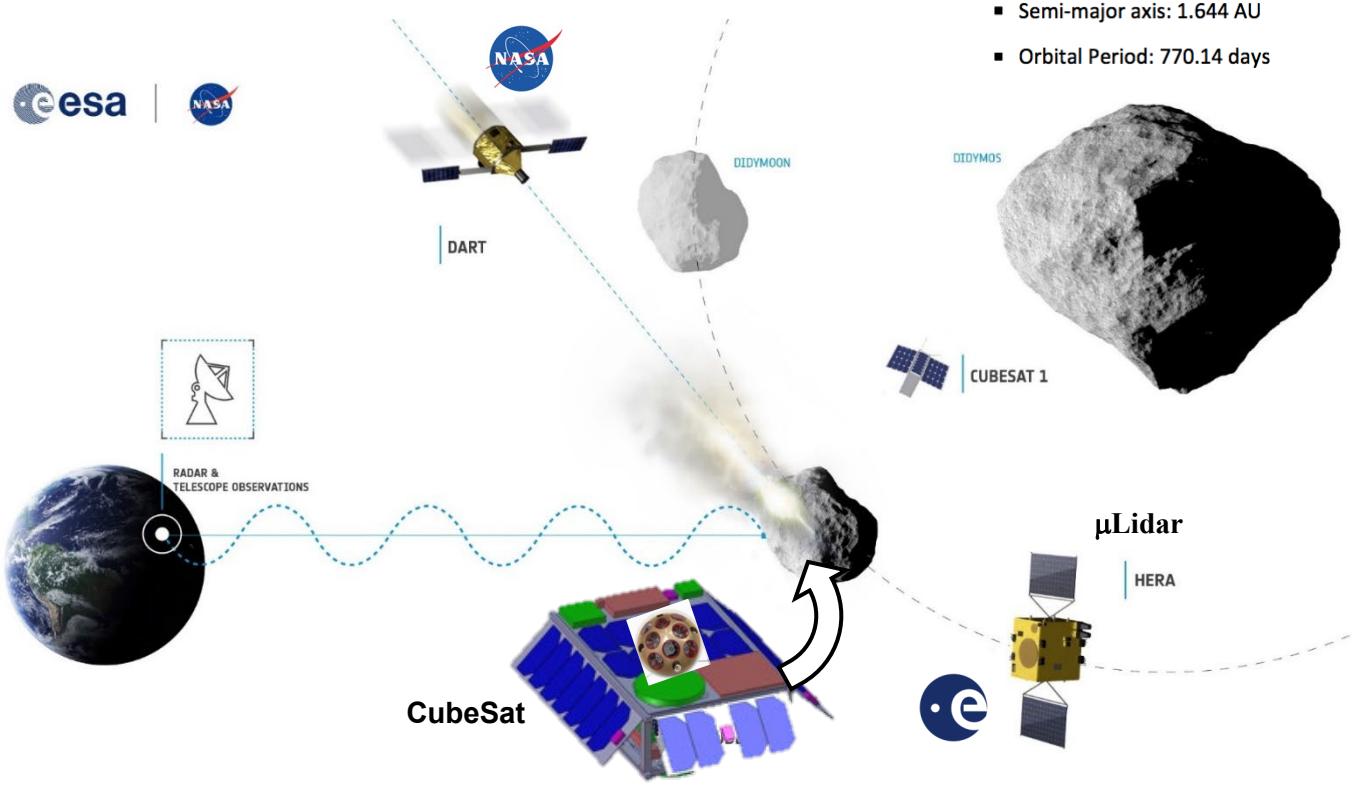
- **INRRI, LaRRI, or LaRA** can find place on the CubeSats which potentially will land on the asteroid at the end-of-life mission;



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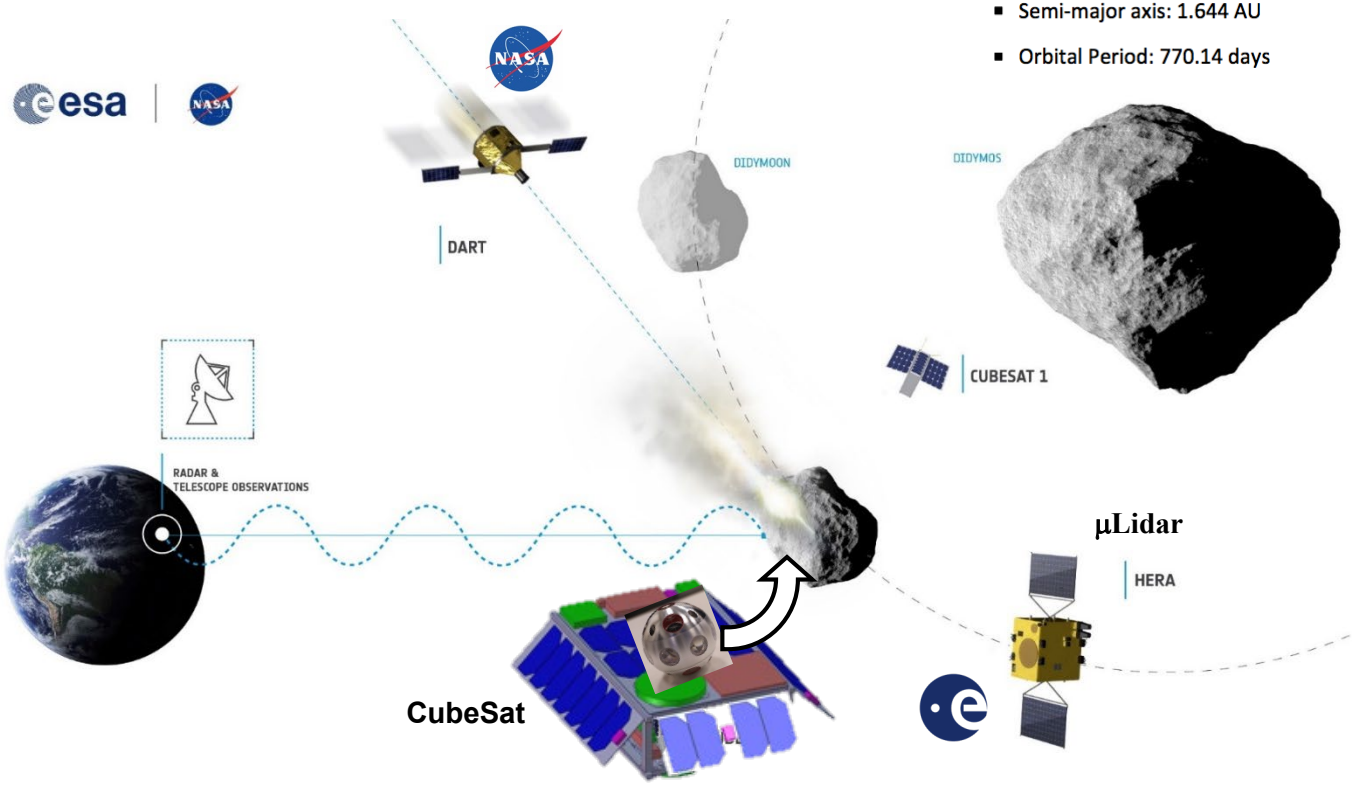
- **COSPHERA** can be landed/dropped on Didymoon's surface by the CubeSats landing at their end-of-life mission.



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Conclusions and Outlooks

Microreflector such as **INRRI**, **LaRRI** and **LaRA** and **COSPHERA** can be employed on missions dedicated to the study of asteroids and comets.

The ESA candidate **Hera** mission will investigate **Didymos** in 2026.

Hera has on-board a μLidar that can perform ToF measurements with our microreflectors:

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Thank you!