

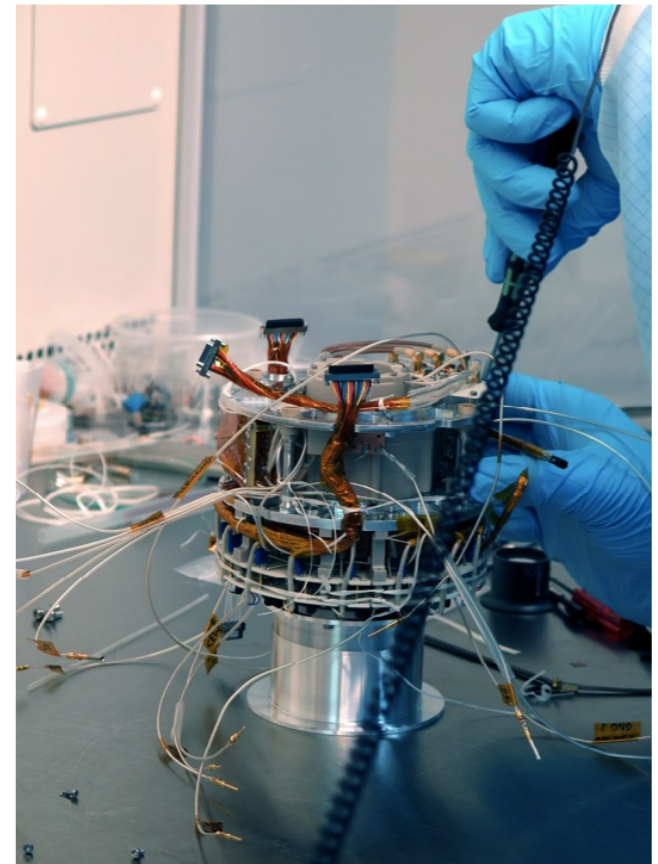
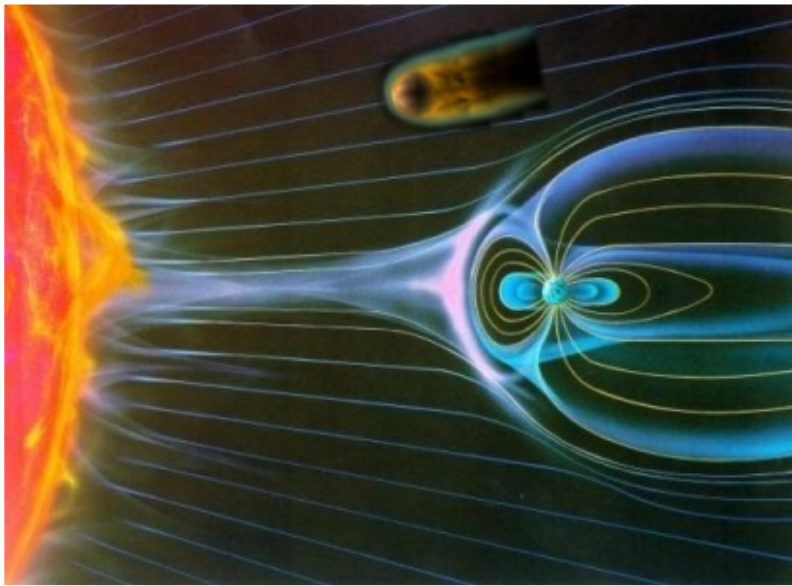
Exploring the Solar System, a Swedish Perspective on Space Science

*Dr Olle Norberg, Director-General
Swedish Institute of Space Physics*



Experimental Space Research at IRF

- Development of scientific instruments and methods to answer the questions:
 - How does the space environment work?
 - How does it interact with planets and systems?



Solar wind interaction with planets, moons, asteroids, and comets

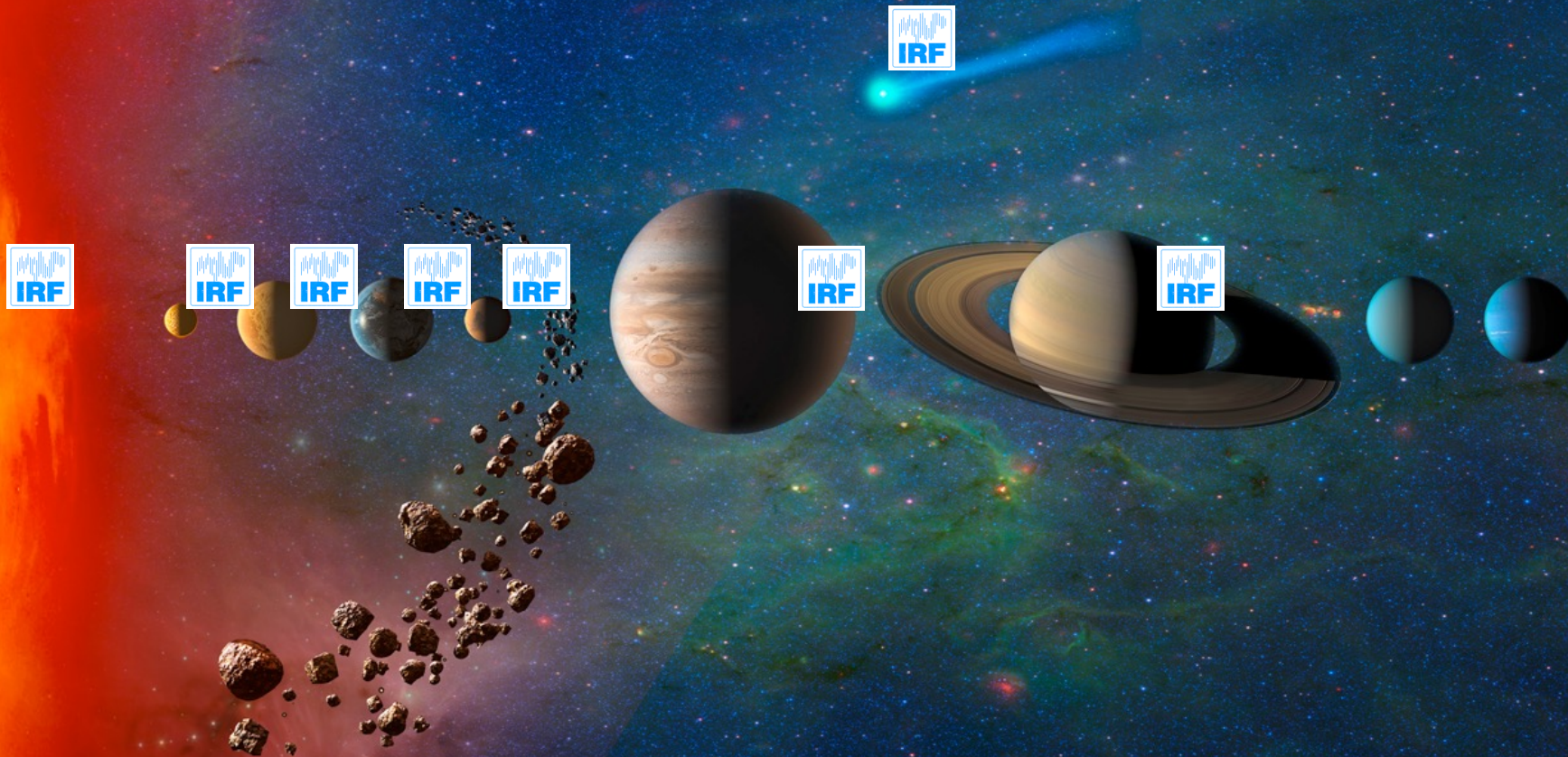
IRF has specialized in research regarding space plasma – charged gas particles and the electric and magnetic fields in the space plasma.

World leading in developing and building certain instrumentation in this area.



57 years with instruments in orbits around the Earth

37 years in the Solar System

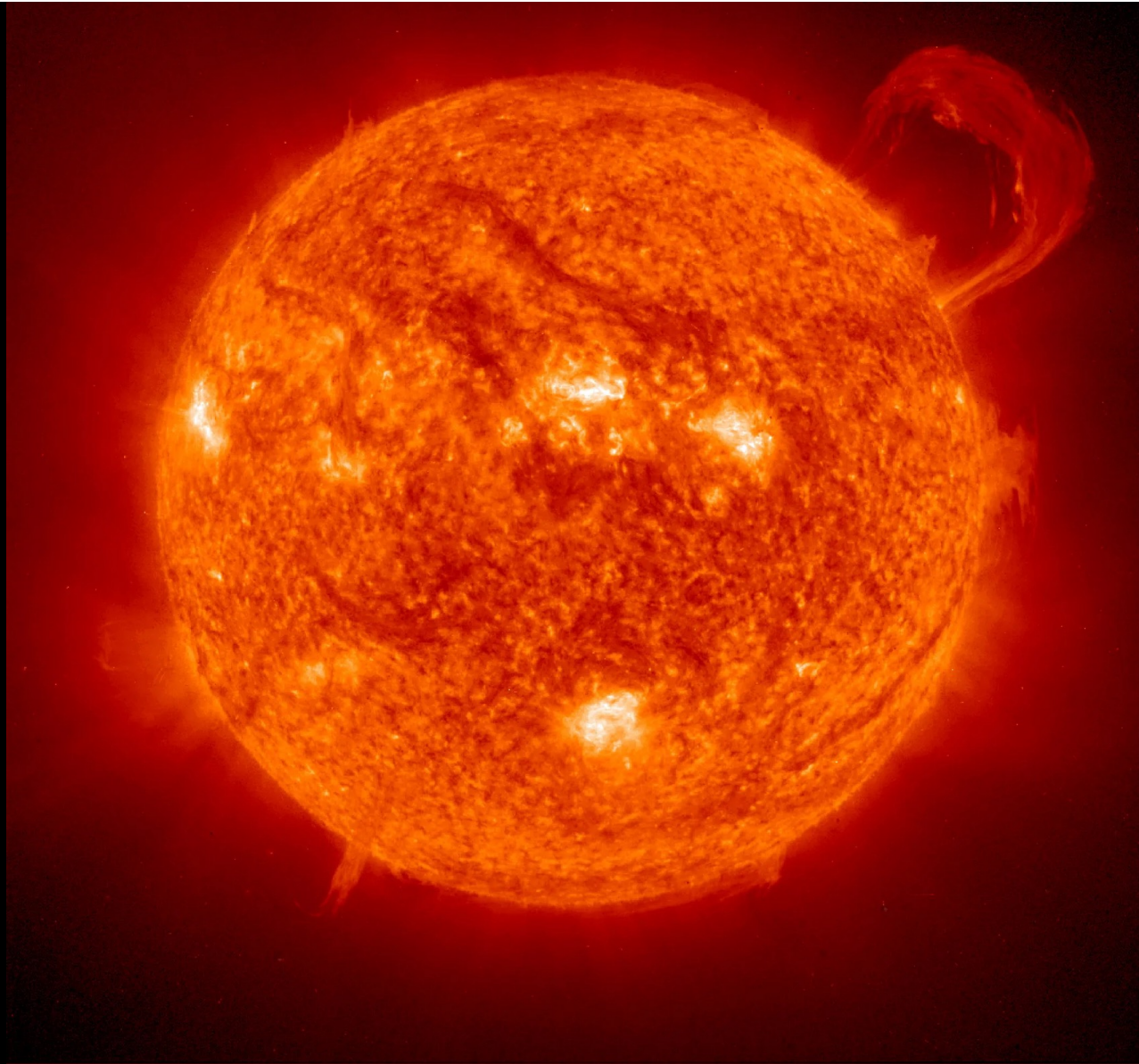




Rymdstyrelsen
Swedish National Space Agency

+ Industry

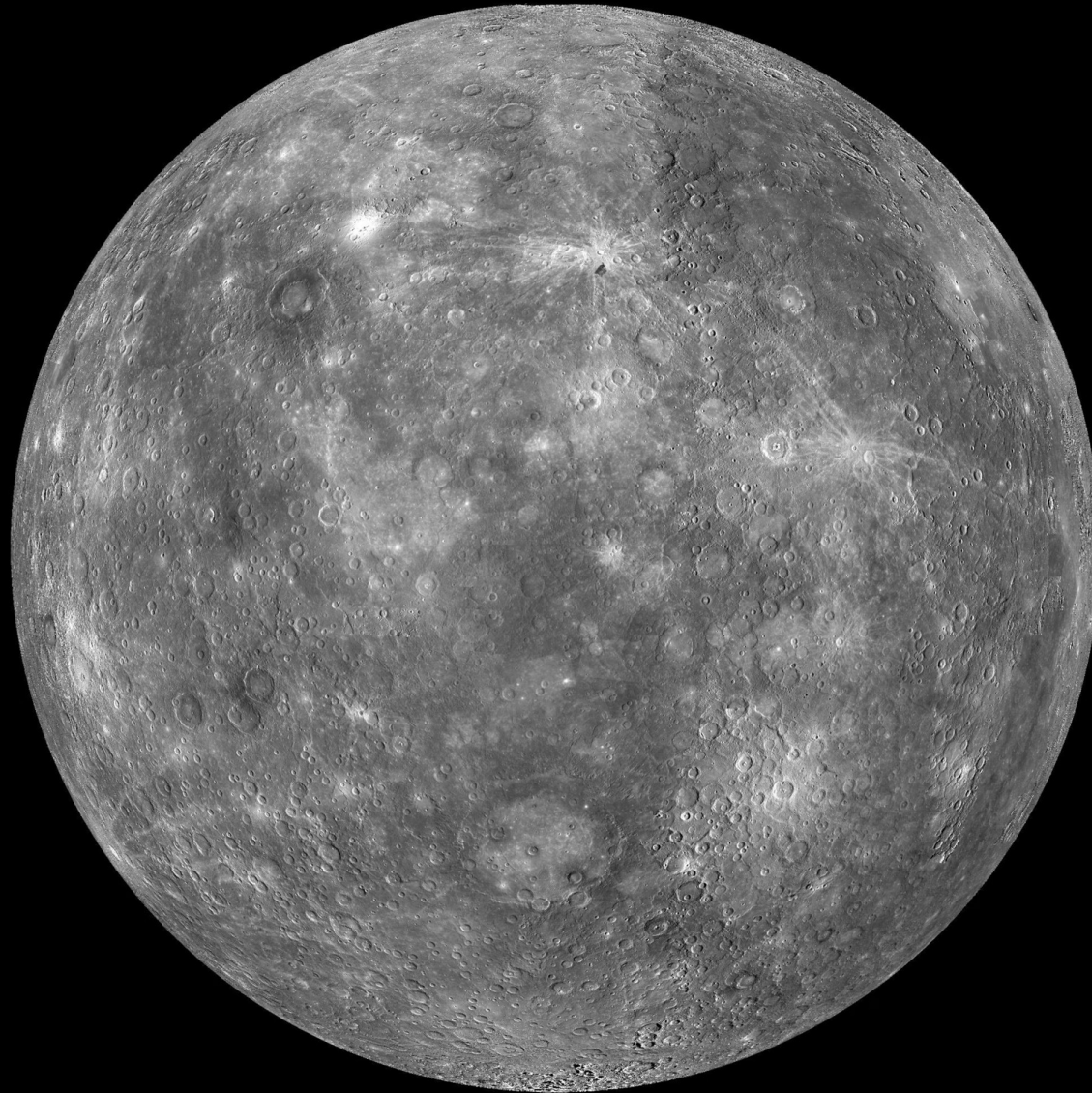
The Sun

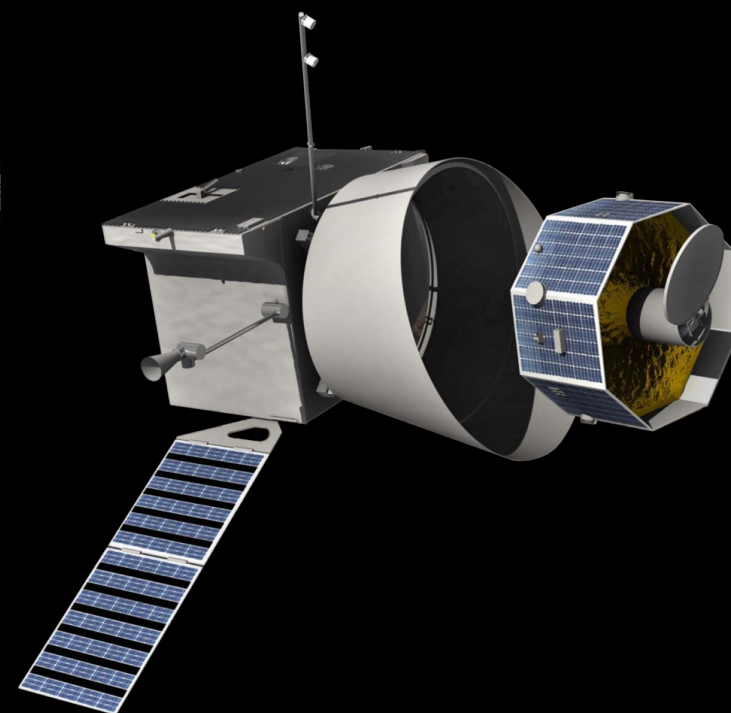
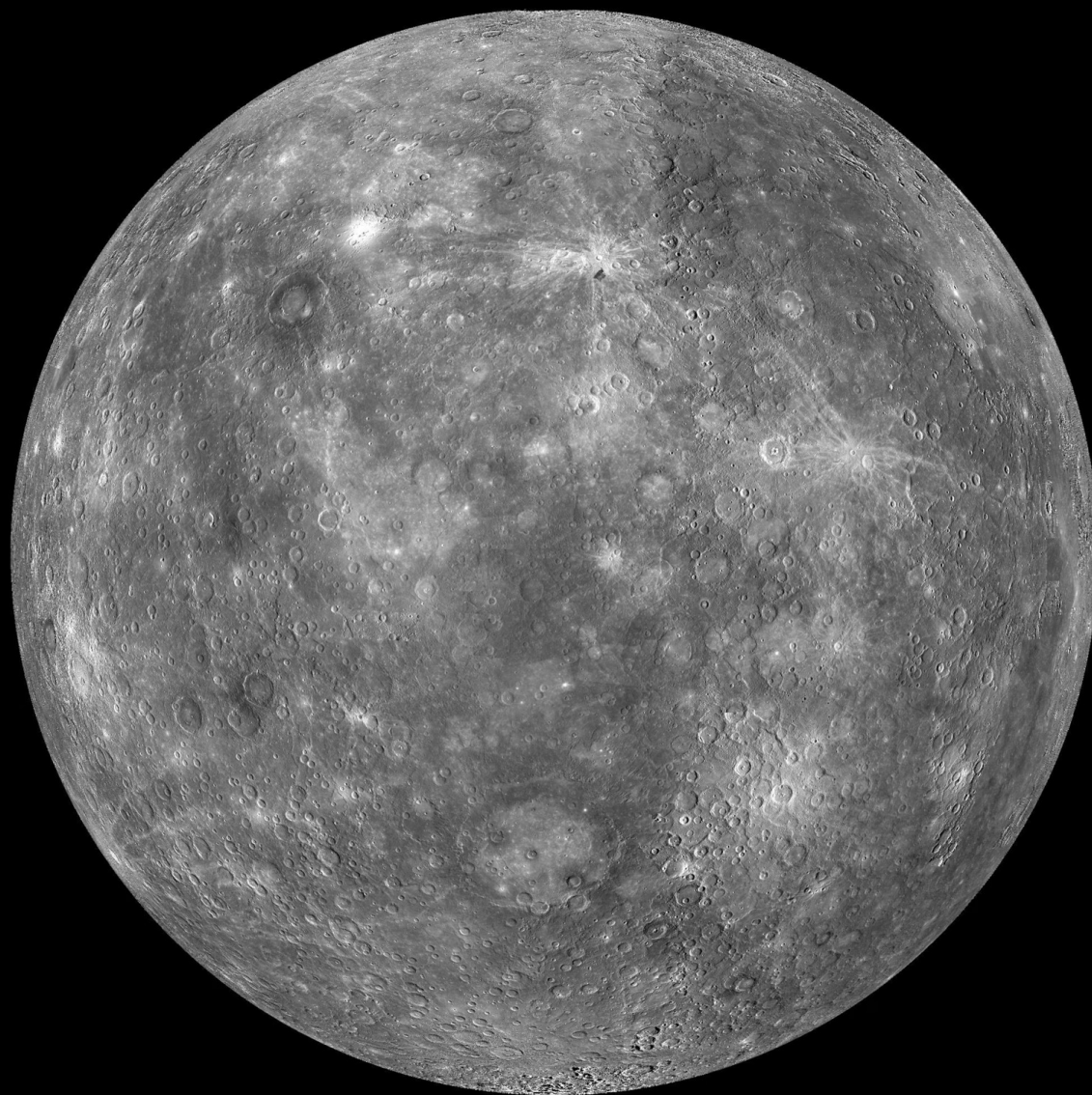


Solar orbiter, launched 2020
The IRF instrument studies
turbulence in solar wind waves



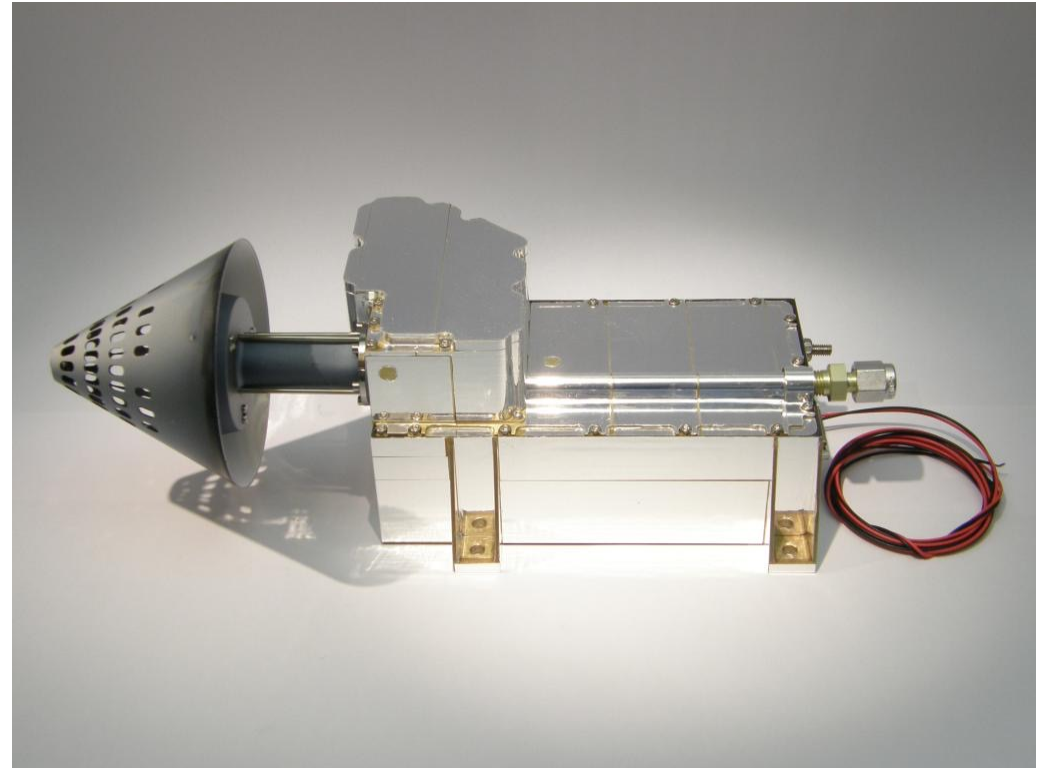
Mercury



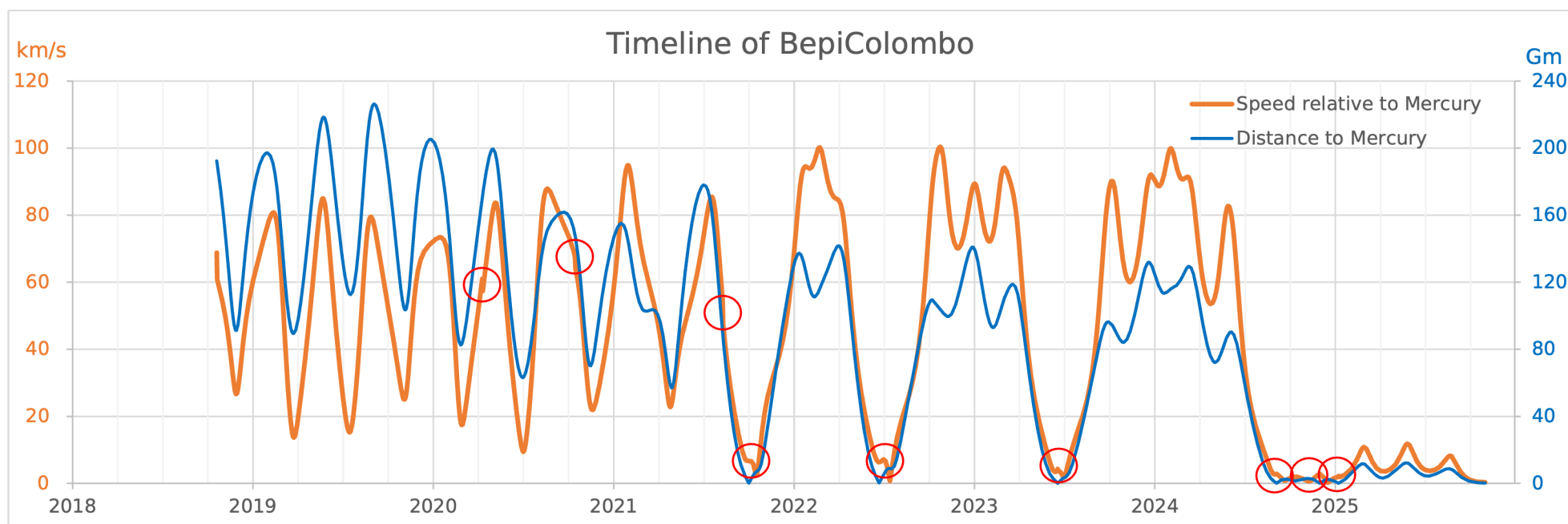


The IRF instruments on BepiColombo

- JAXA Mercury Magnetosphere Orbiter (Mio): Neutral particles
- ESA's Mercury Planetary Orbiter: Positive ions



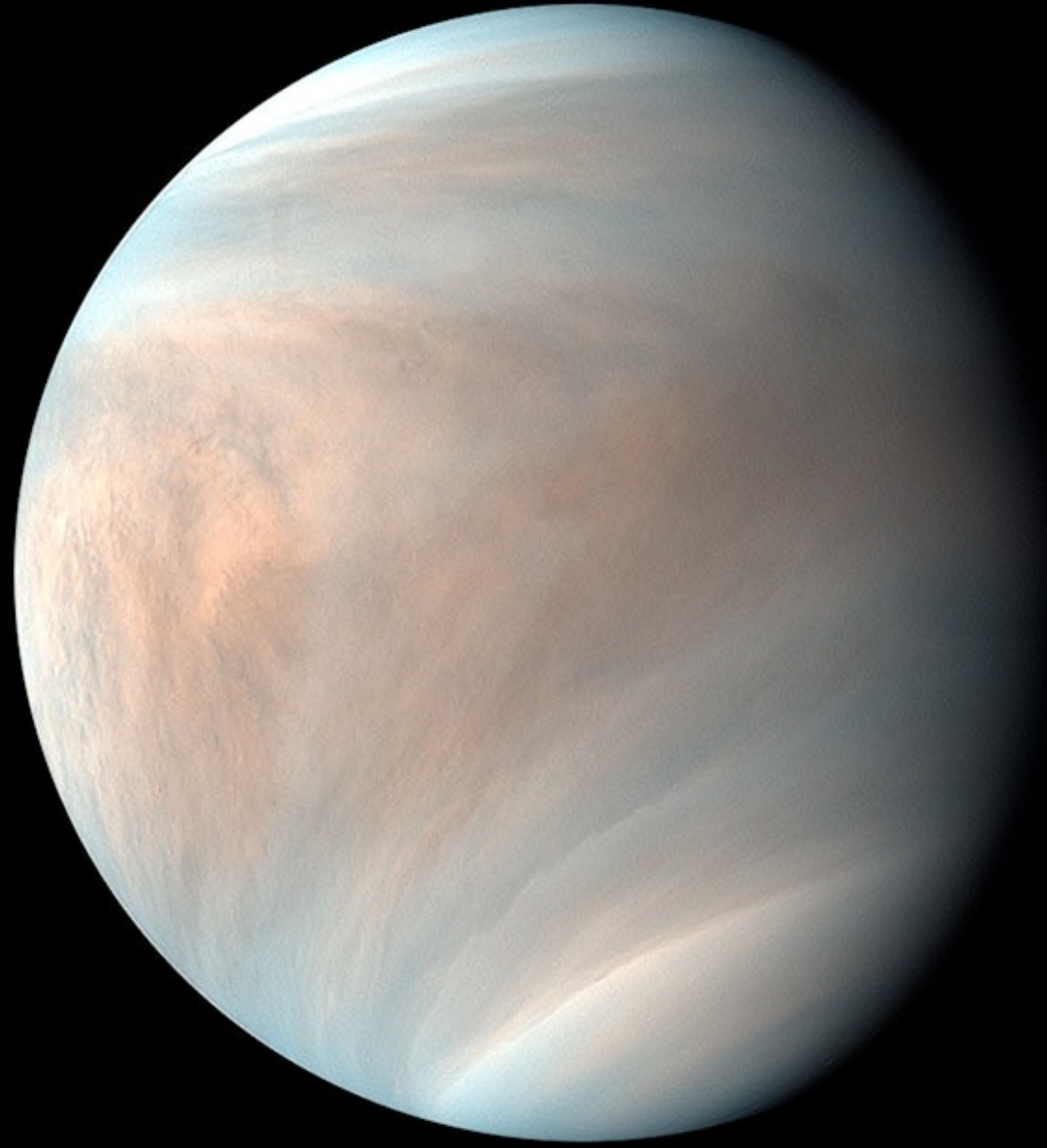
The journey to Mercury is difficult!

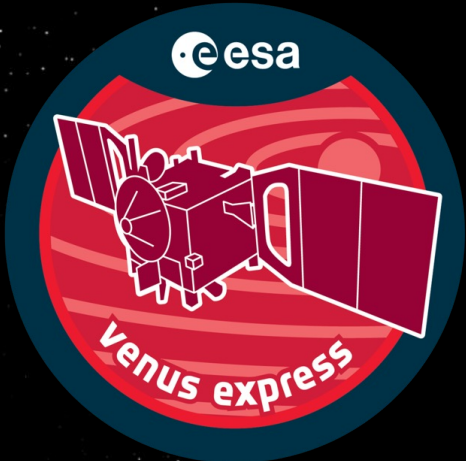
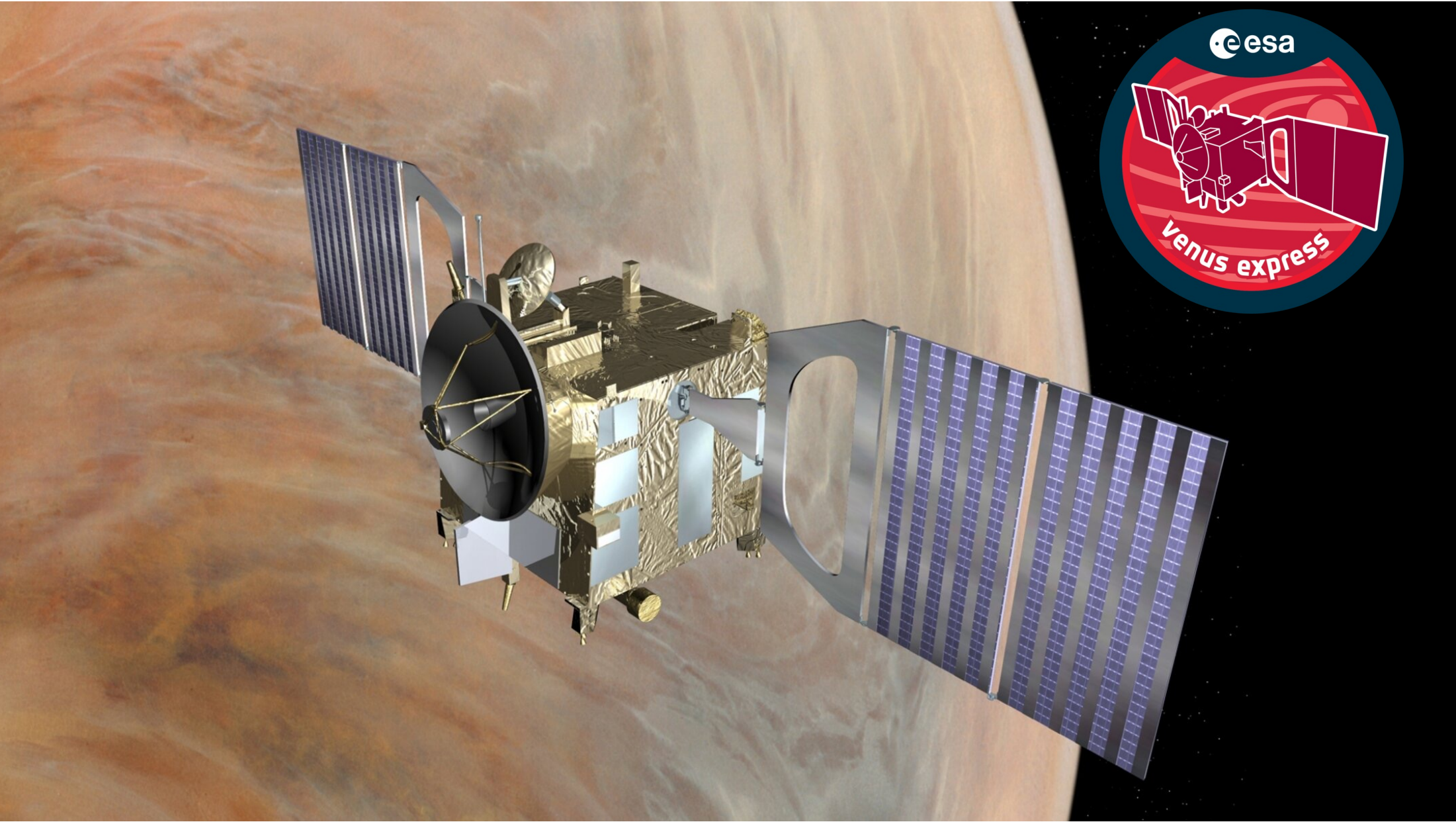


Typical travel times inside the Solar System

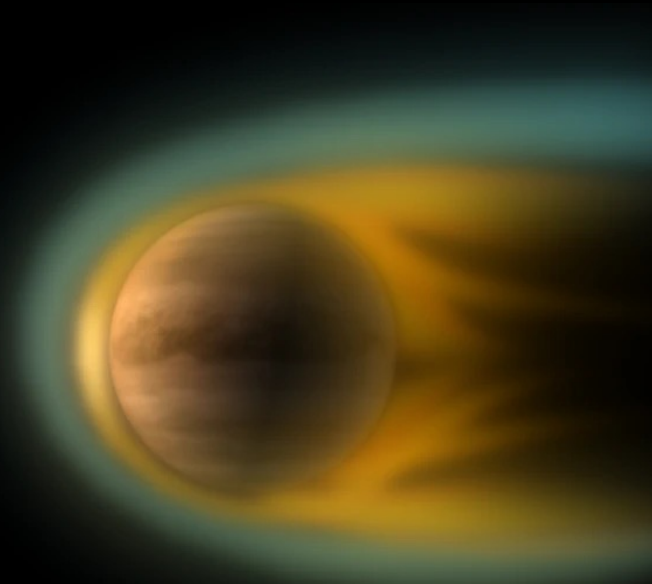
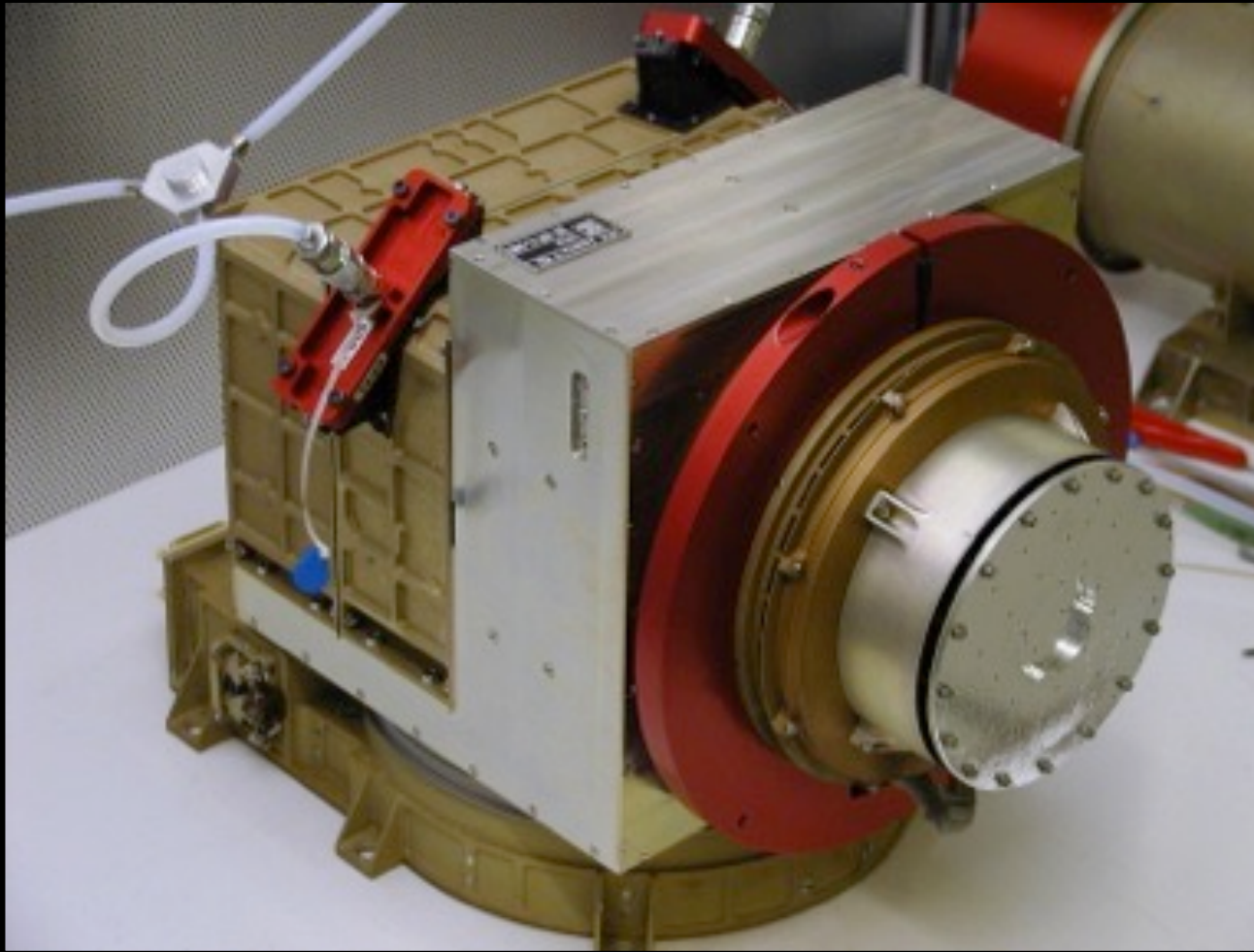
Destination	Typical travel time
Moon	3 - 5 days
Venus	4 - 6 months
Mars	6 - 9 months
Mercury	6 - 7 years
Jupiter	5 - 8 years
Uranus	8 - 14 years

Venus



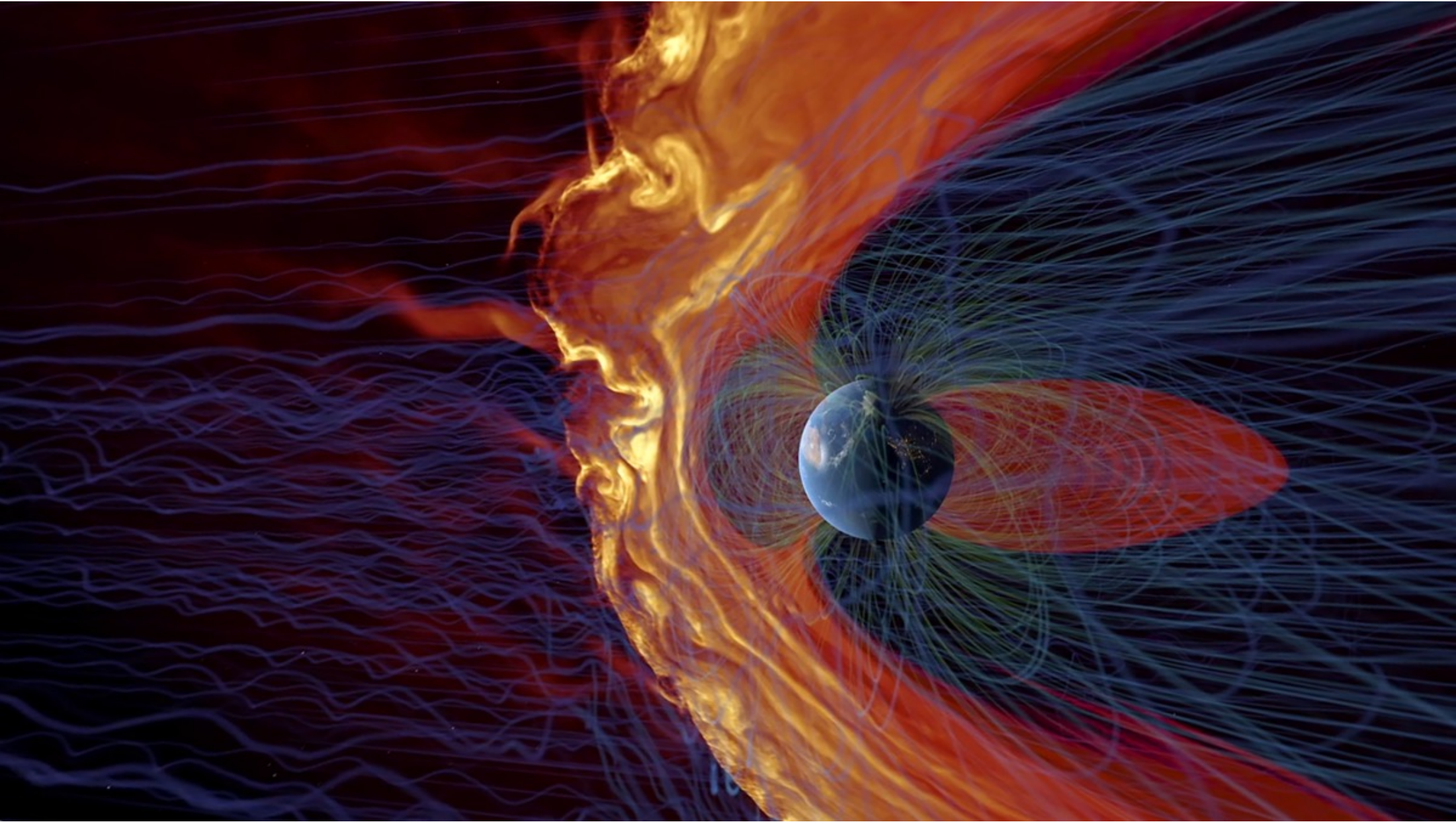


The IRF instrument ASPERA-4 on Venus Express

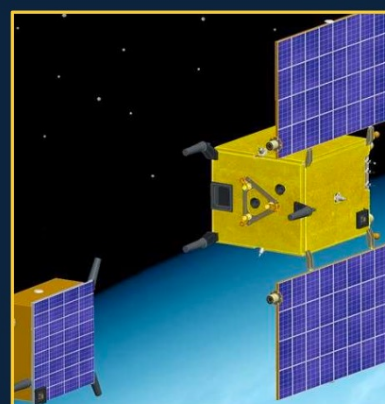
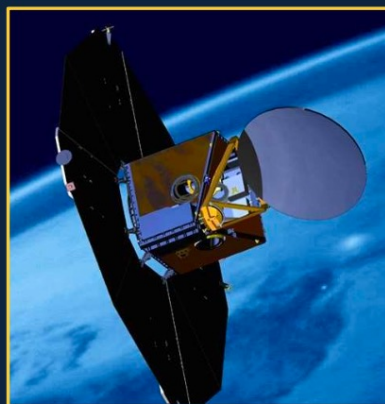


The Earth





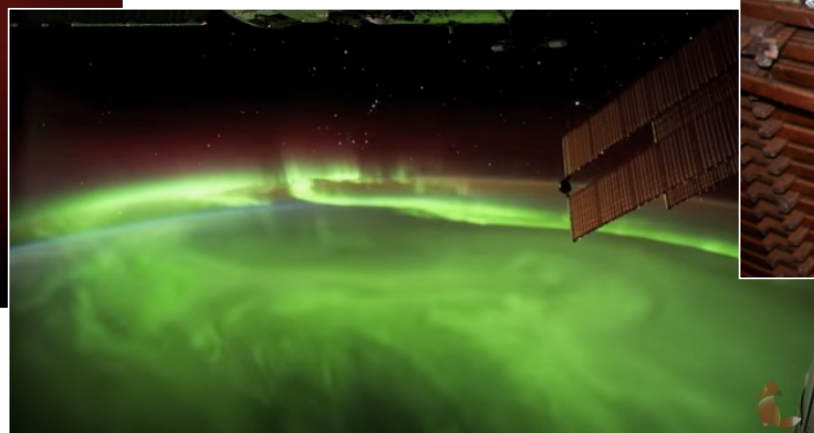
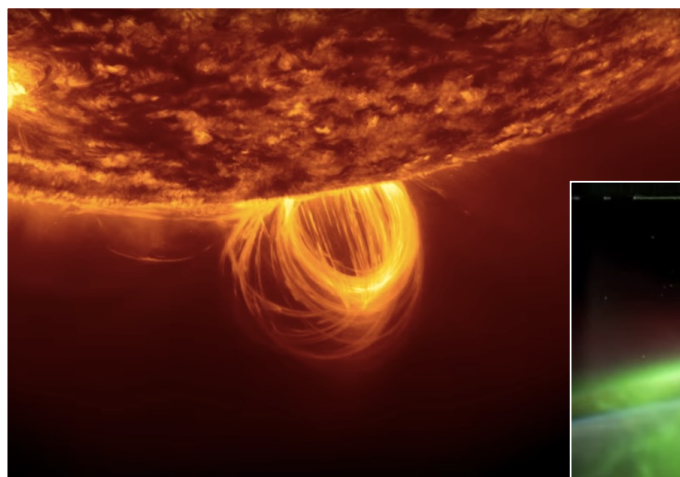
Swedish National satellites





Applications of our research: Space Weather

- How does solar storms and the space environment affect infrastructure in space and on the ground?
- Observations, research, forecasts and national warnings
- Stakeholders: ESA, Swedish Armed Forces, power grid operators, Swedish Civil Contingencies Agency



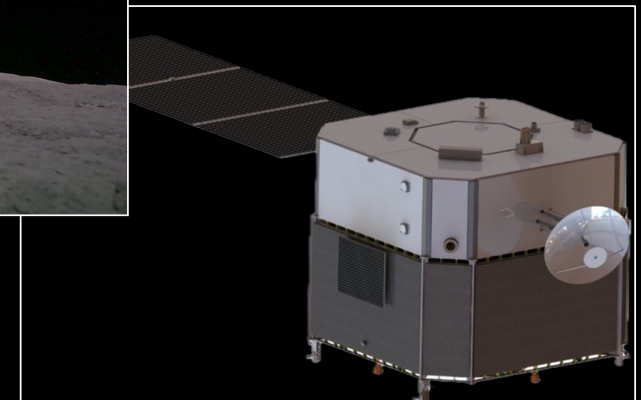
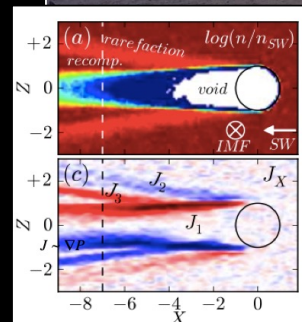
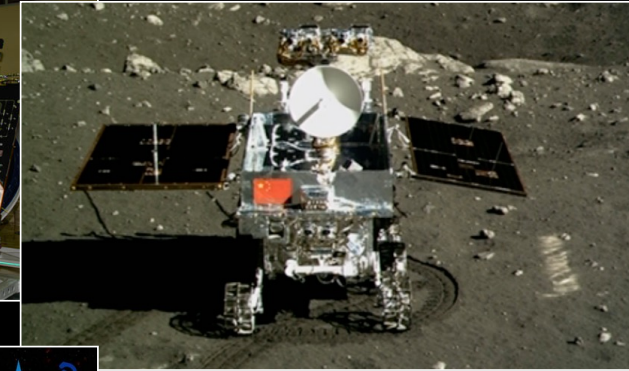
CT Gaunt / NCU

The Moon

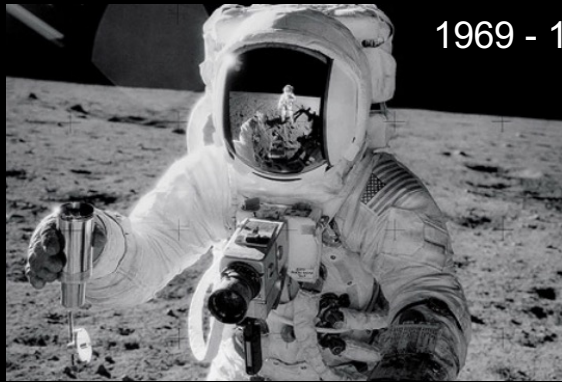


IRF and lunar research

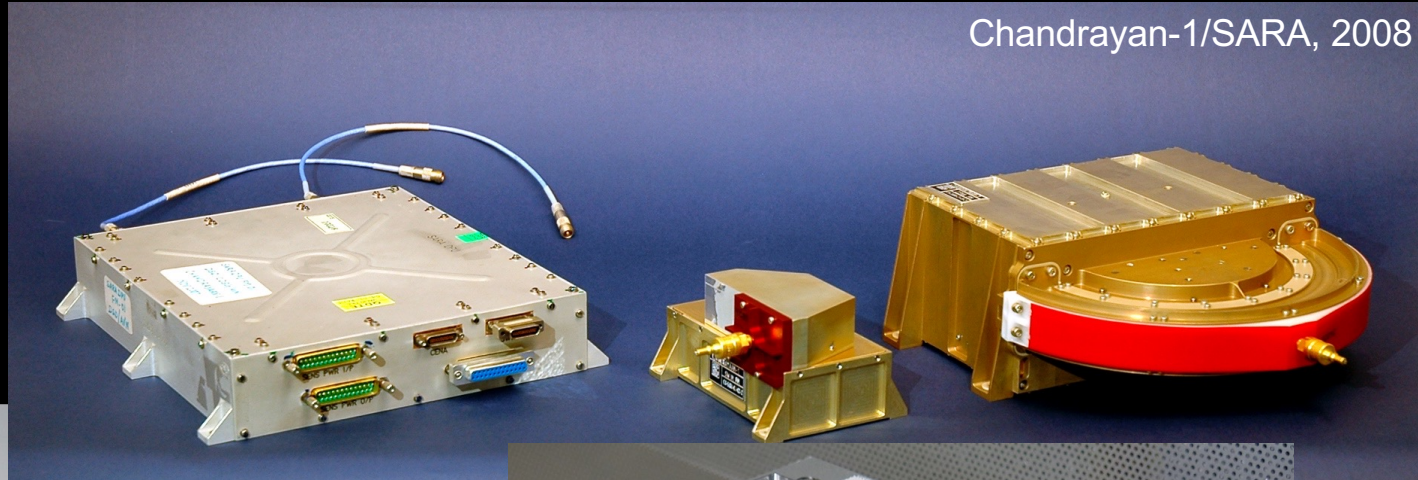
- IRF is at the forefront of lunar plasma research in Europe
- Mission participation
 - ESA SMART-1
 - ISRO Chandrayan-1
 - CNSA Chang'e 4, Chang'e 6
 - *Turkish AYAP-1*
 - *ESA Argonaut*
- Extensive numerical simulations



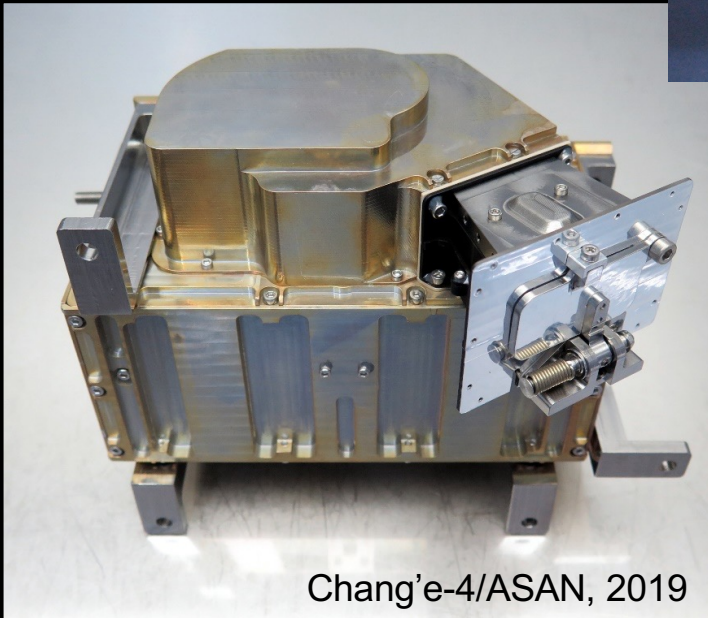
Swedish instruments on the Moon



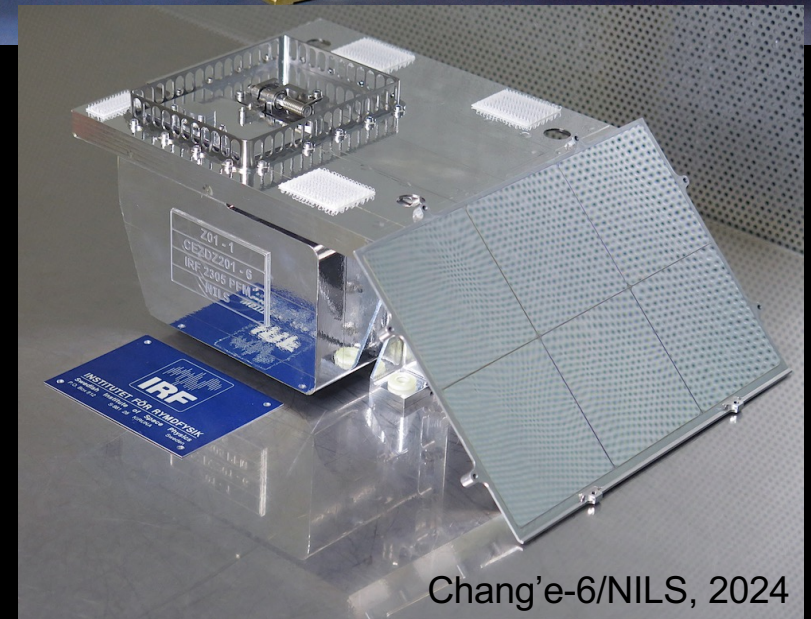
1969 - 1972



Chandrayan-1/SARA, 2008



Chang'e-4/ASAN, 2019



Chang'e-6/NILS, 2024

Space plasma science enabling exploration

Lunar plasma knowledge is essential for:

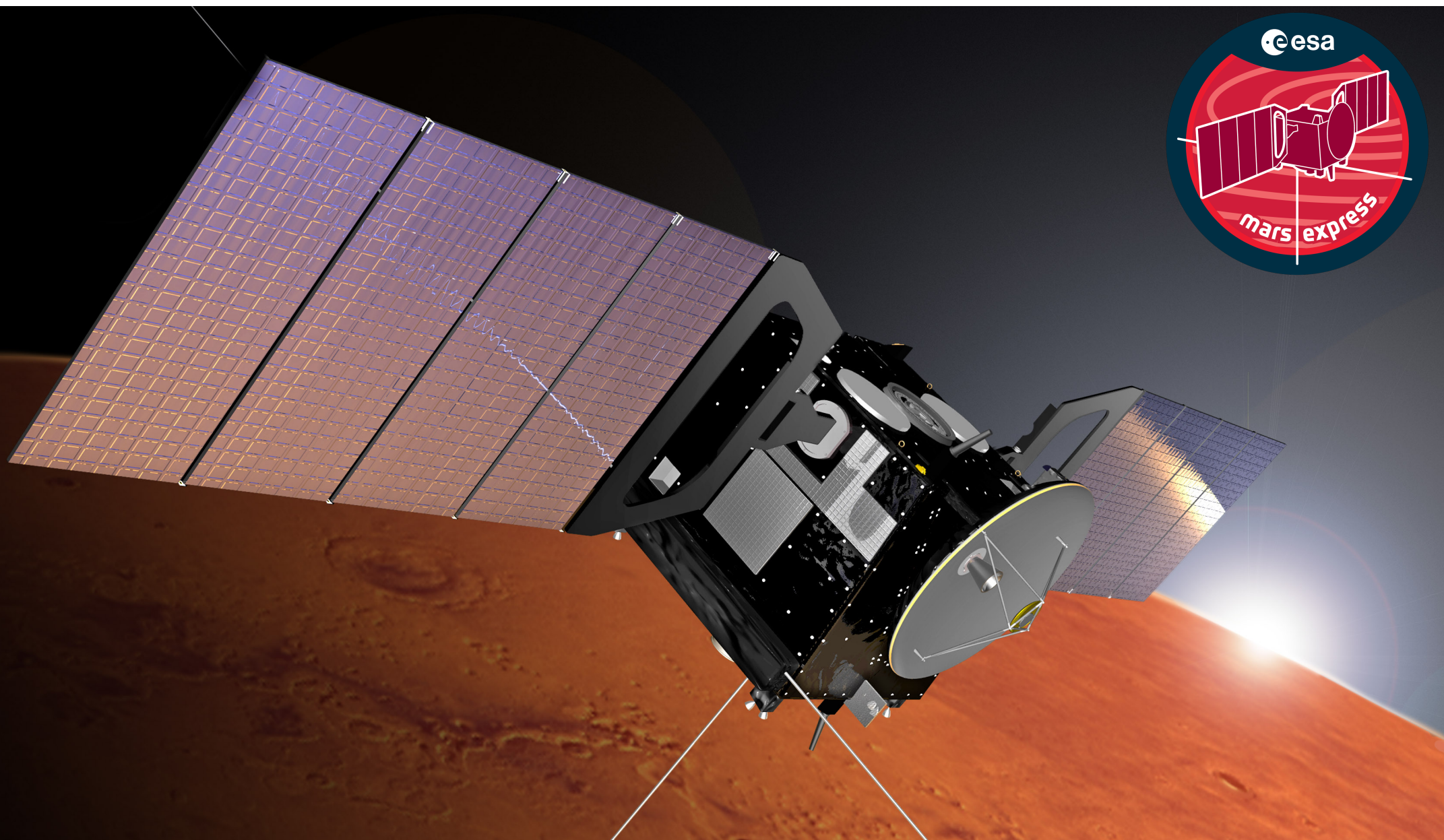
- Accurate charging models (surface + hardware)
- Predicting and managing dust behaviour and dust interactions



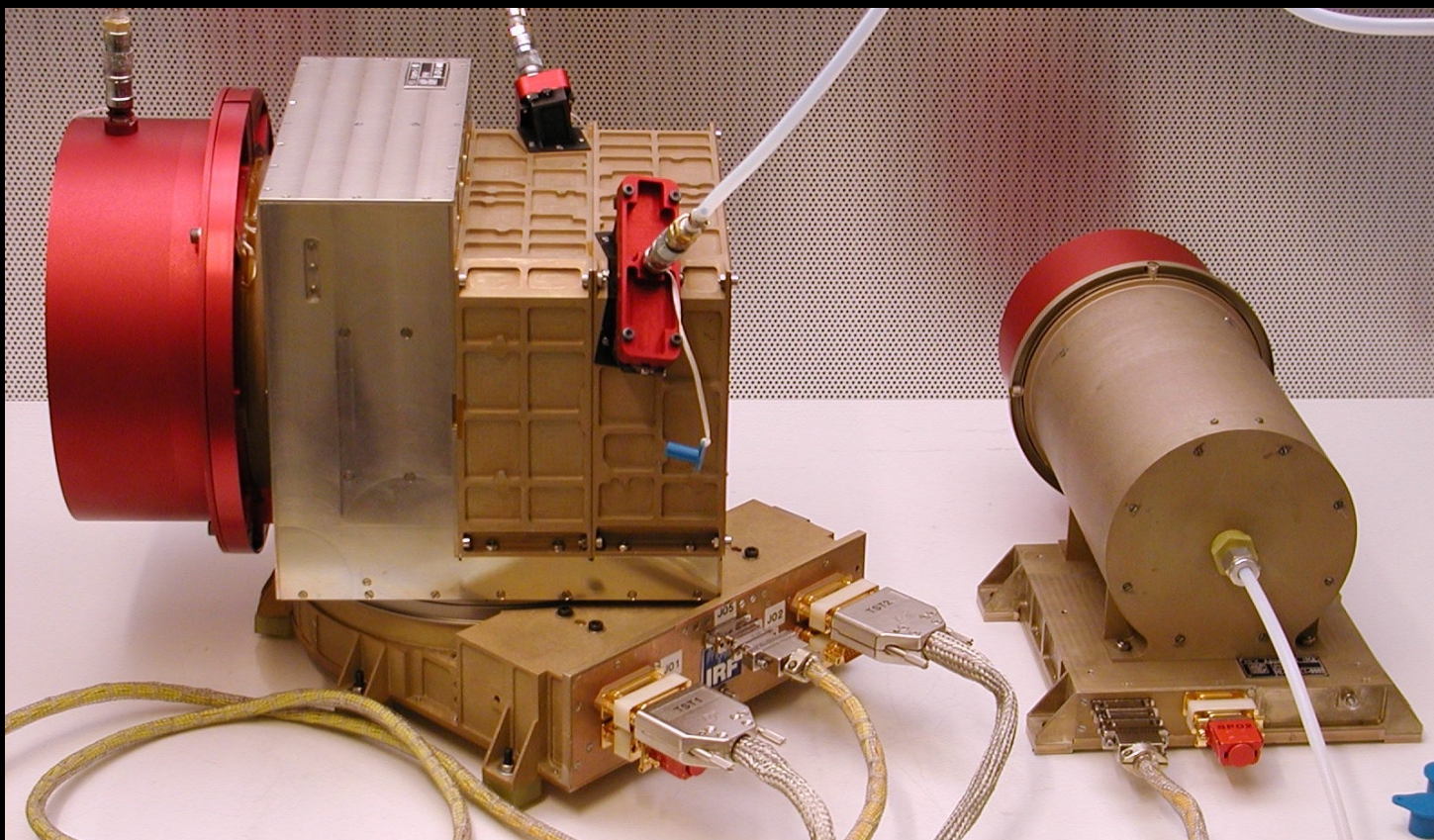
*Apollo image AS17-134-20472. Apollo 17 astronaut Jack Schmitt. **Very dusty!***

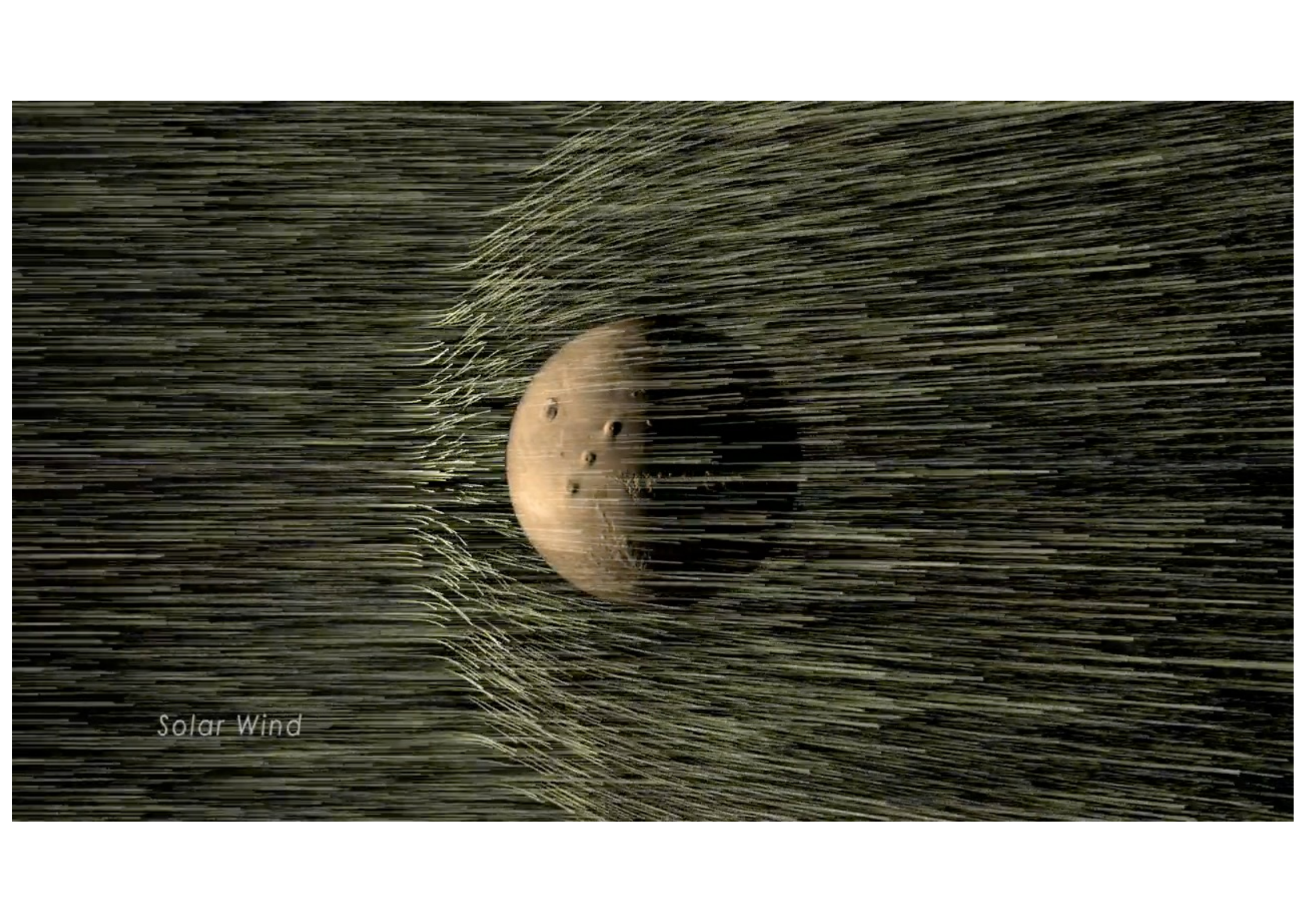
Mars





IRF's instrument
ASPERA-3 on
Mars Express –
still fully
operational after
22 years!





Solar Wind



The answer to dangerous asteroids – Planetary Defense!



NASA's Double Asteroid Redirection Test (DART)

Target: Dimorphos

Impact 26 September 2022

Relative velocity: 6.1 km/s

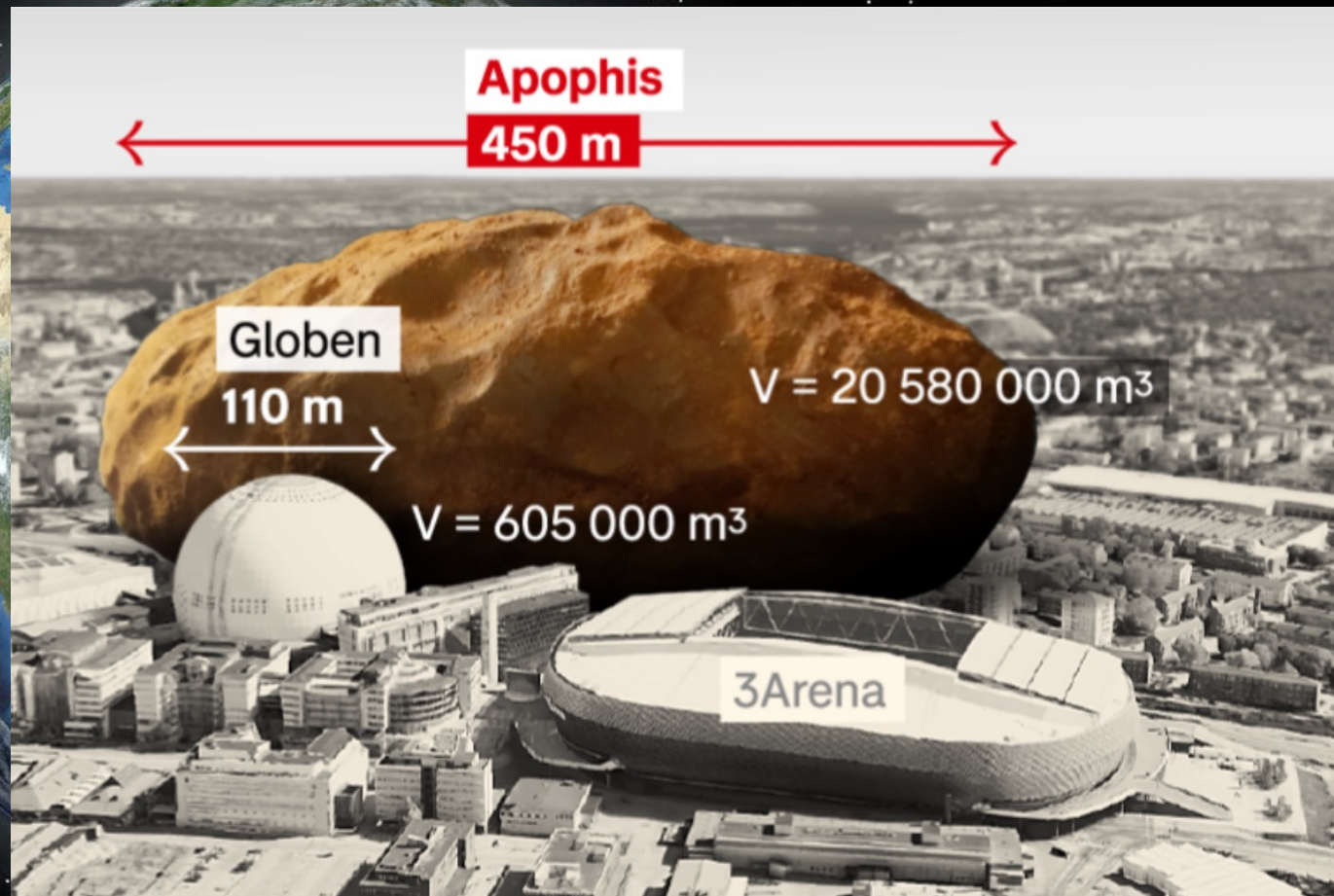
Follow-up by ESA's HERA,
arrives December 2026



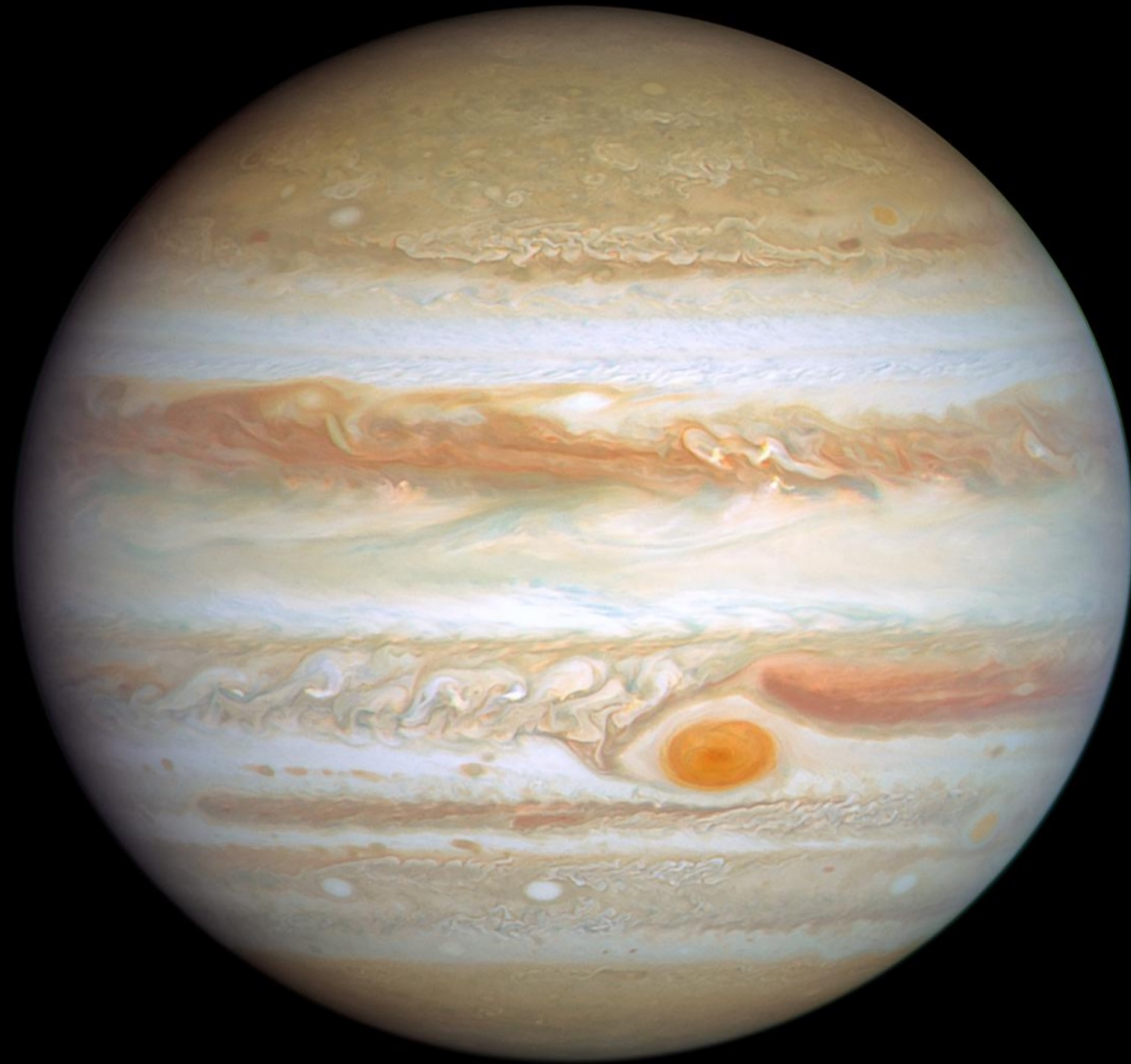


Apophis
13 April 2029



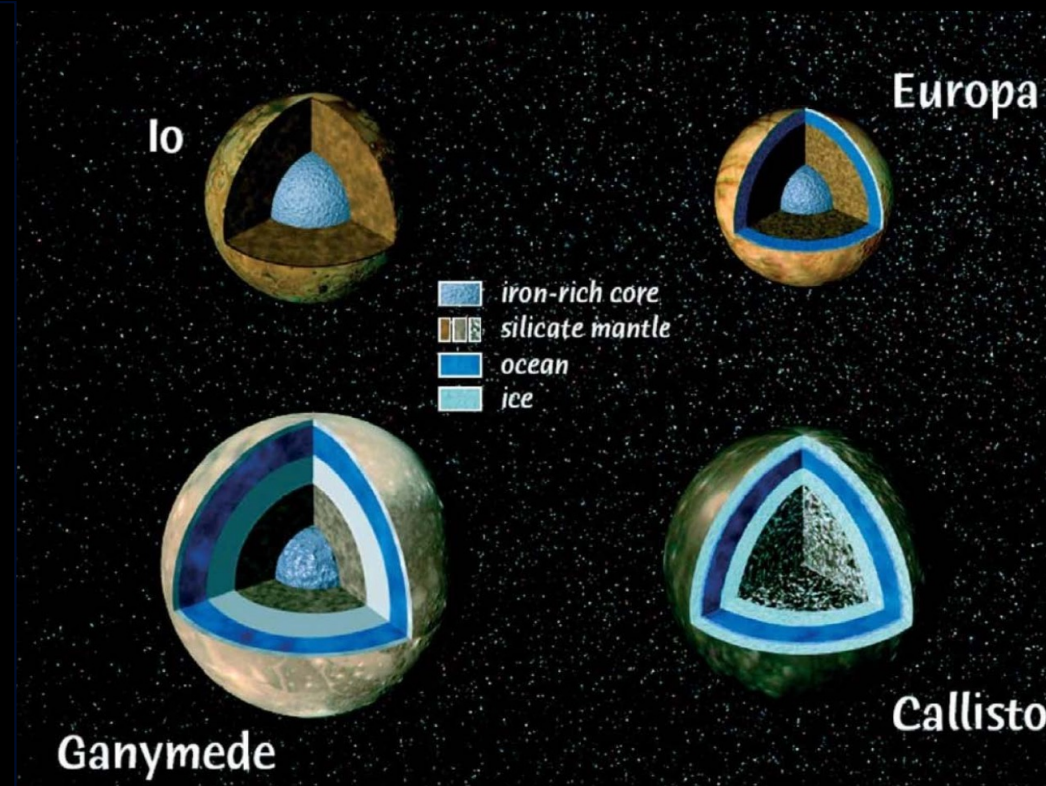


Jupiter



The ESA JUICE mission, Jupiter Icy Moons Explorer, launched on 14 April 2023
Arrives at Jupiter in July 2031
Will study Europa, Ganymede, and Callisto





Europa

- A deep ocean
- An active world?
- **Best example of liquid environment in contact with silicates**

Ganymede

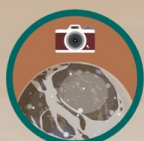
- Largest satellite in the solar system
- A deep ocean
- Internal dynamo and an induced magnetic field – unique
- Richest crater morphologies
- **Archetype of waterworlds**
- **Best example of liquid environment**

Callisto

- Best place to study the impactor history
- Differentiation – still an enigma
- Only known example of non active but ocean-bearing world
- The witness of early ages

MEET THE TEAM: INSTRUMENT PRINCIPAL INVESTIGATORS

[Click here](#) for a full list of Juice instruments with technical descriptions, principal investigators, co-principal investigators and lead funding agencies.



Optical camera system (JANUS)

Pasquale Palumbo
Università degli Studi di Napoli
Parthenope
Italy



UV imaging spectrograph (UVS)

Randy Gladstone
Southwest Research Institute
USA



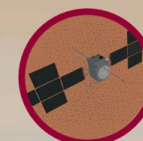
Radar sounder (RIME)

Lorenzo Bruzzone
Università degli Studi di Trento
Italy



Radio science experiment (3GM)

Luciano Iess
Sapienza Università di Roma
Italy



Particle environment package (PEP)

Stas Barabash
Institutet för rymdfysik
Kiruna, Sweden



Visible and infrared imaging spectrometer (MAJIS)

François Poulet
Institut d'Astrophysique Spatiale
France



Sub-millimetre wave instrument (SWI)

Paul Hartogh
Max-Planck-Institut für
Sonnensystemforschung
Germany



Laser altimeter (GALA)

Hauke Hussmann
DLR Institut für Planetenforschung
Germany



Magnetometer (J-MAG)

Michele Dougherty
Imperial College London
United Kingdom



Radio and plasma wave instrument (RPWI)

Jan-Erik Wahlund
Institutet för rymdfysik
Uppsala, Sweden

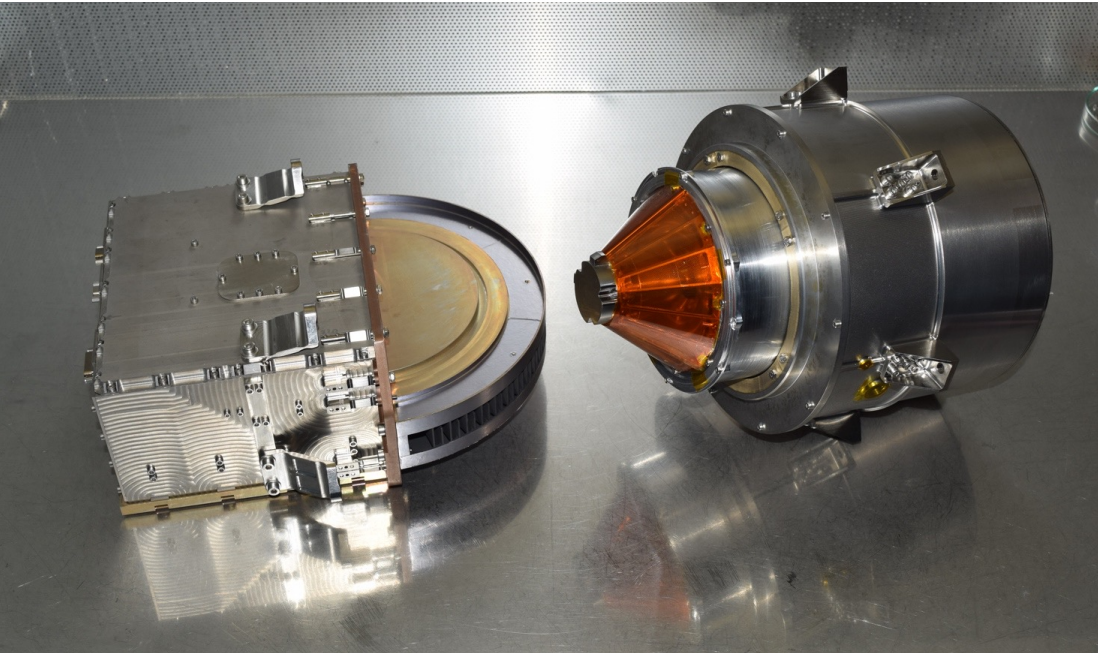


Planetary Radio Interferometer & Doppler Experiment (PRIDE)

Leonid Gurvits
Joint Institute for VLBI ERIC and Technische Universiteit Delft
Netherlands









solarsystem.nasa.gov

