
esa
Fundamental Physics in ESA Science
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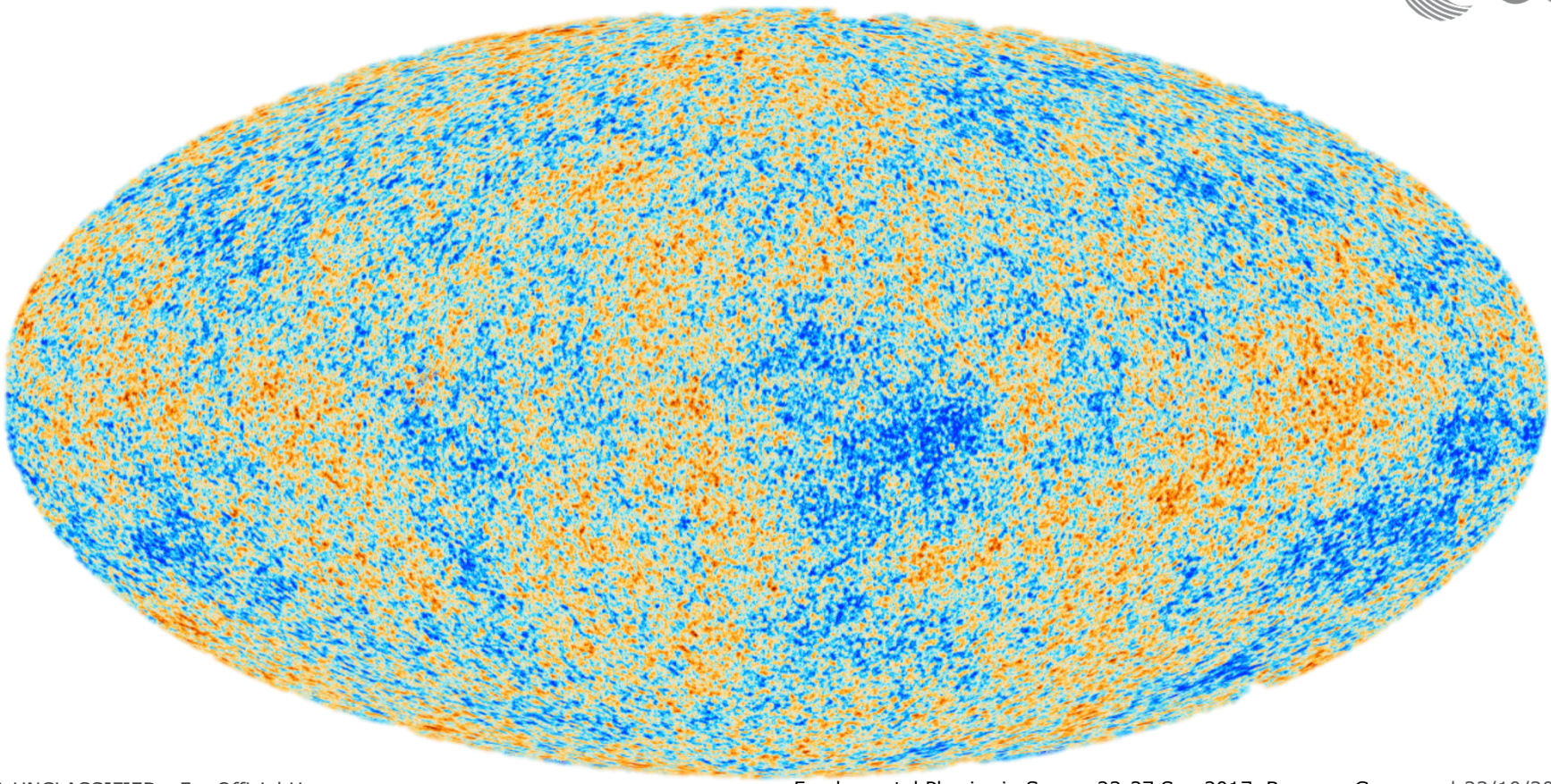
European Space Agency

ESA missions with FP aspects

- Existing/past missions
  - Planck
  - Gaia
  - LISA Pathfinder
- Future missions
  - Bepi Colombo
  - Euclid
  - LISA
- GNSS (Galileo)
- New initiatives

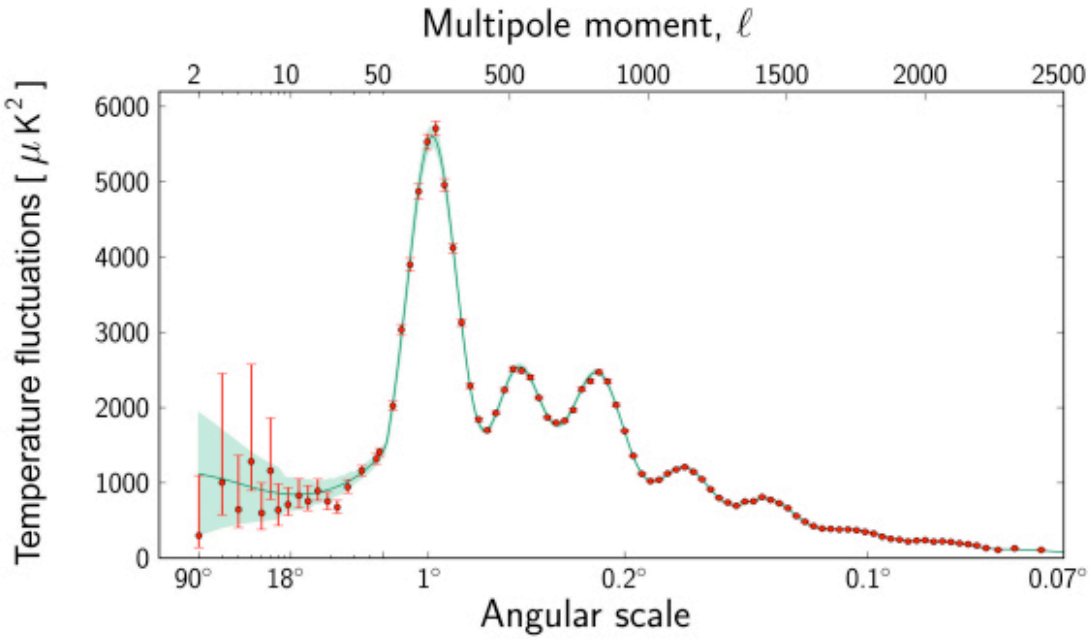
Planck

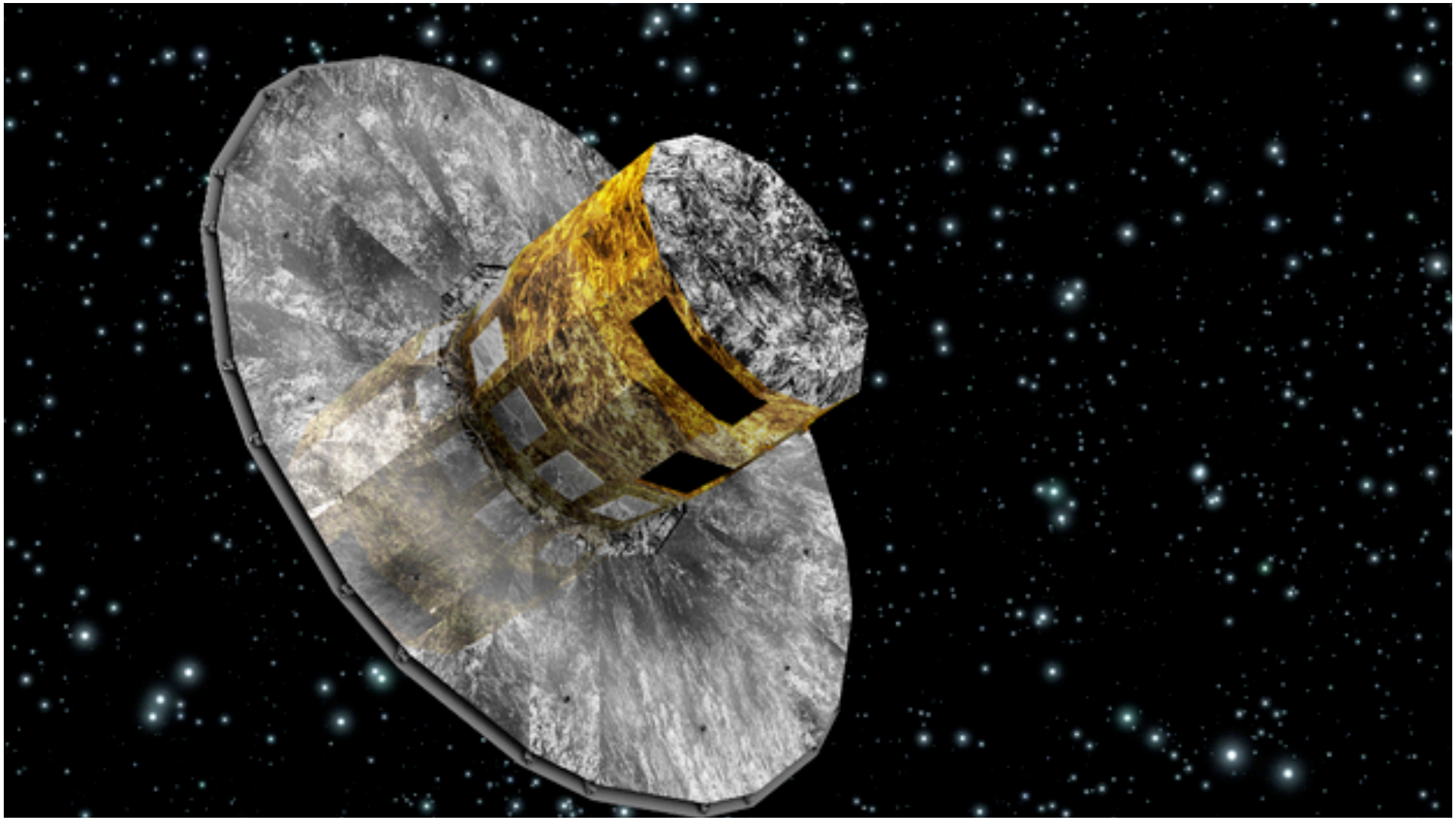


Planck

Planck refined measurements of CMB

Determined Hubble's constant and the densities of baryonic matter, dark matter and dark energy
(Ω_b, Ω_m, Ω_Λ)

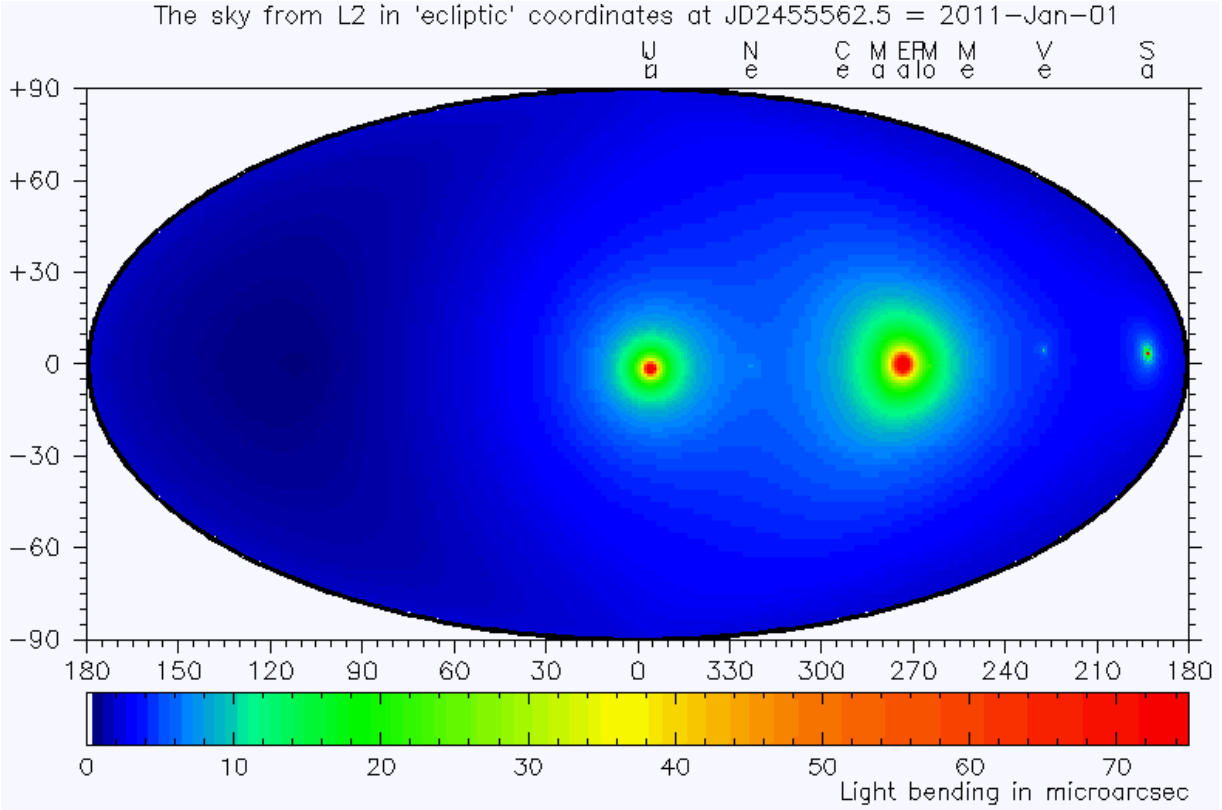


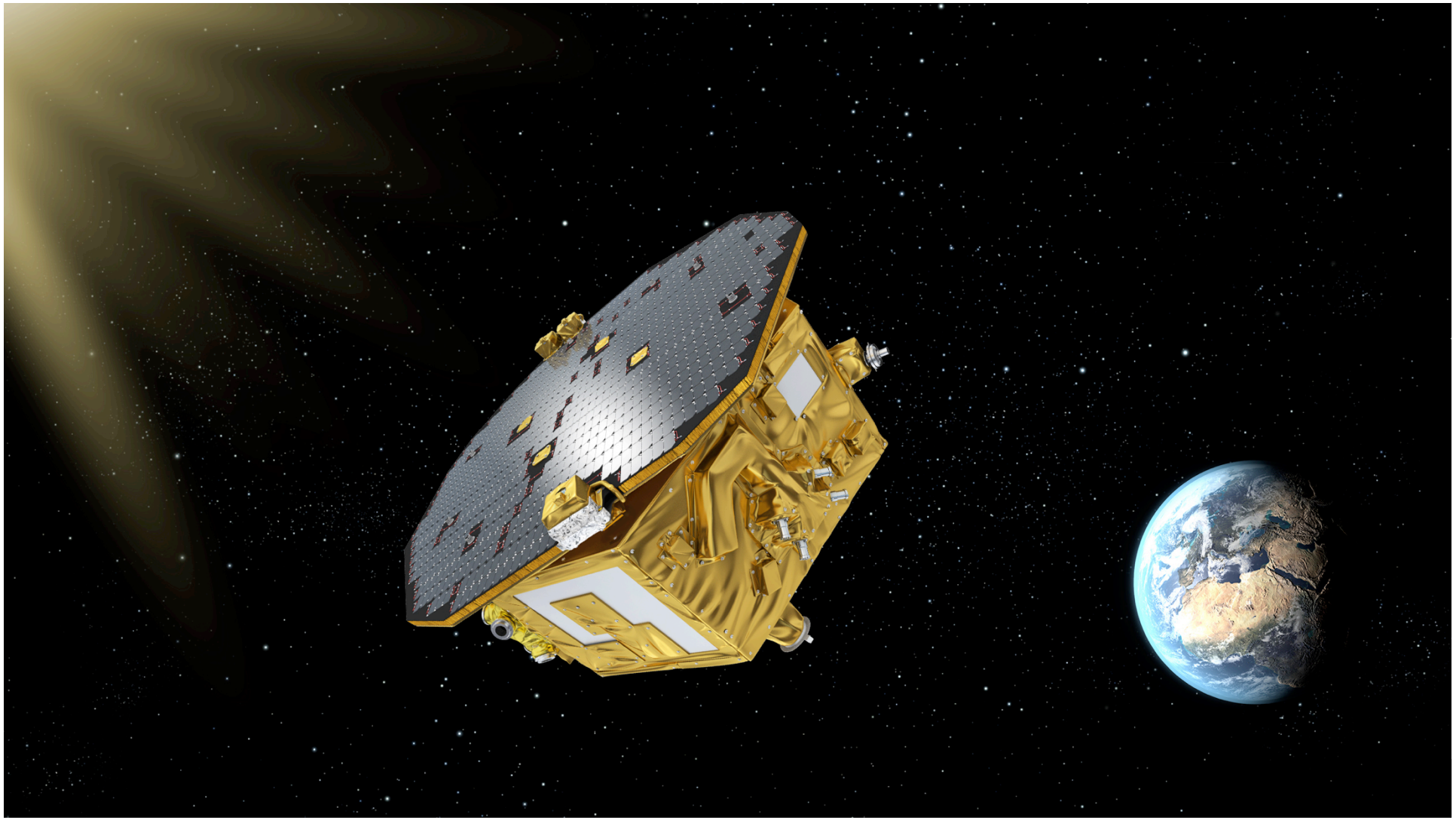


Gaia

- Astrometry mission – determining the position, radial velocity, proper motion, spectroscopy of a billion stars
- A lot of solar system objects ‘accidentally’ observed as well
- Determination of post-Newtonian parameters through light deflection
- Talk by Stefan Jordan on Tuesday

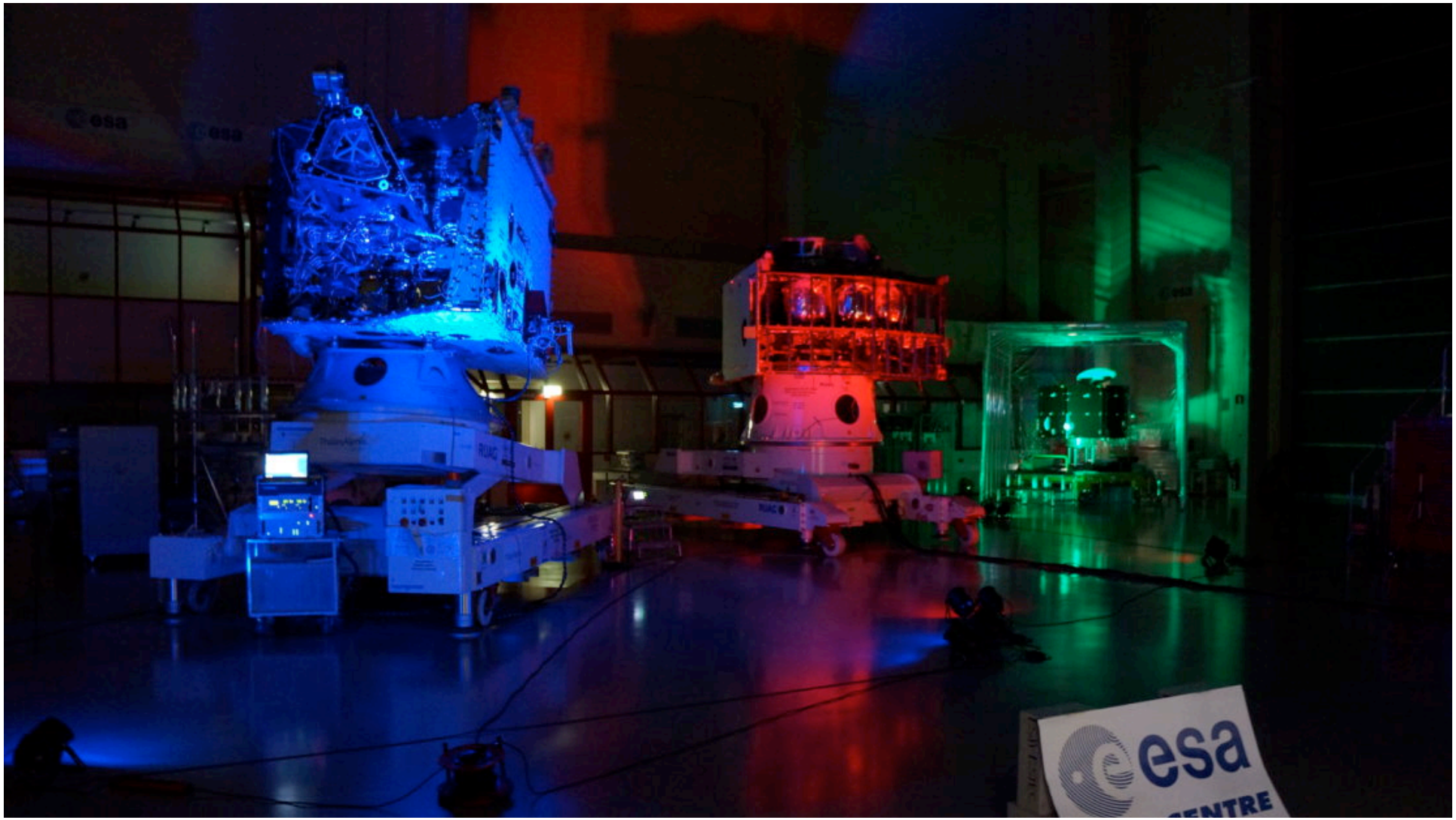
Light deflection





LISA Pathfinder

- Conceived as a technology demonstrator for LISA
  - Demonstrate the crucial technology for ‘free flight’ of test masses
  - Launched in December 2015
  - Successfully completed mission in July 2017
  - Exceeded expectations by a large margin
  - Best demonstration of free flight
    - Remaining forces ~fN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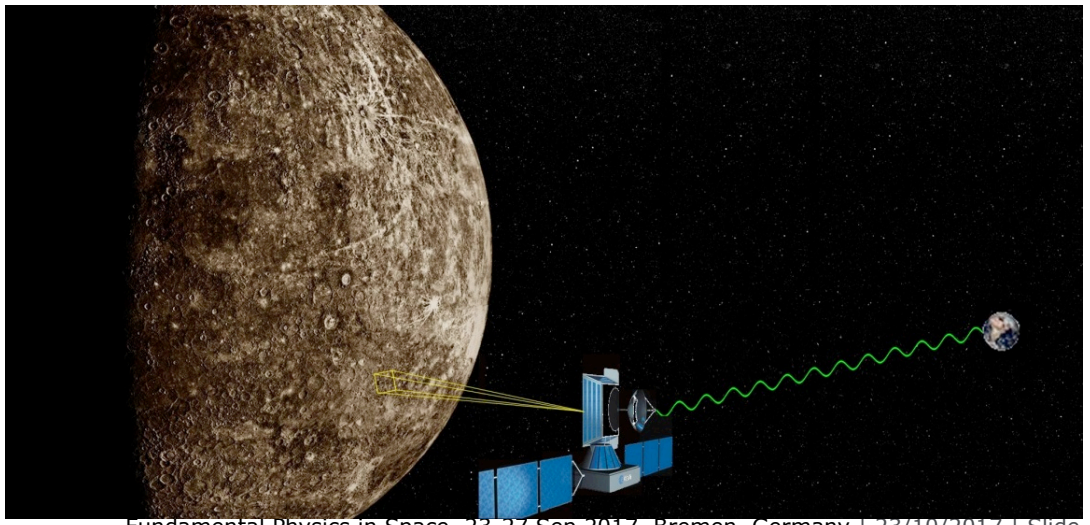
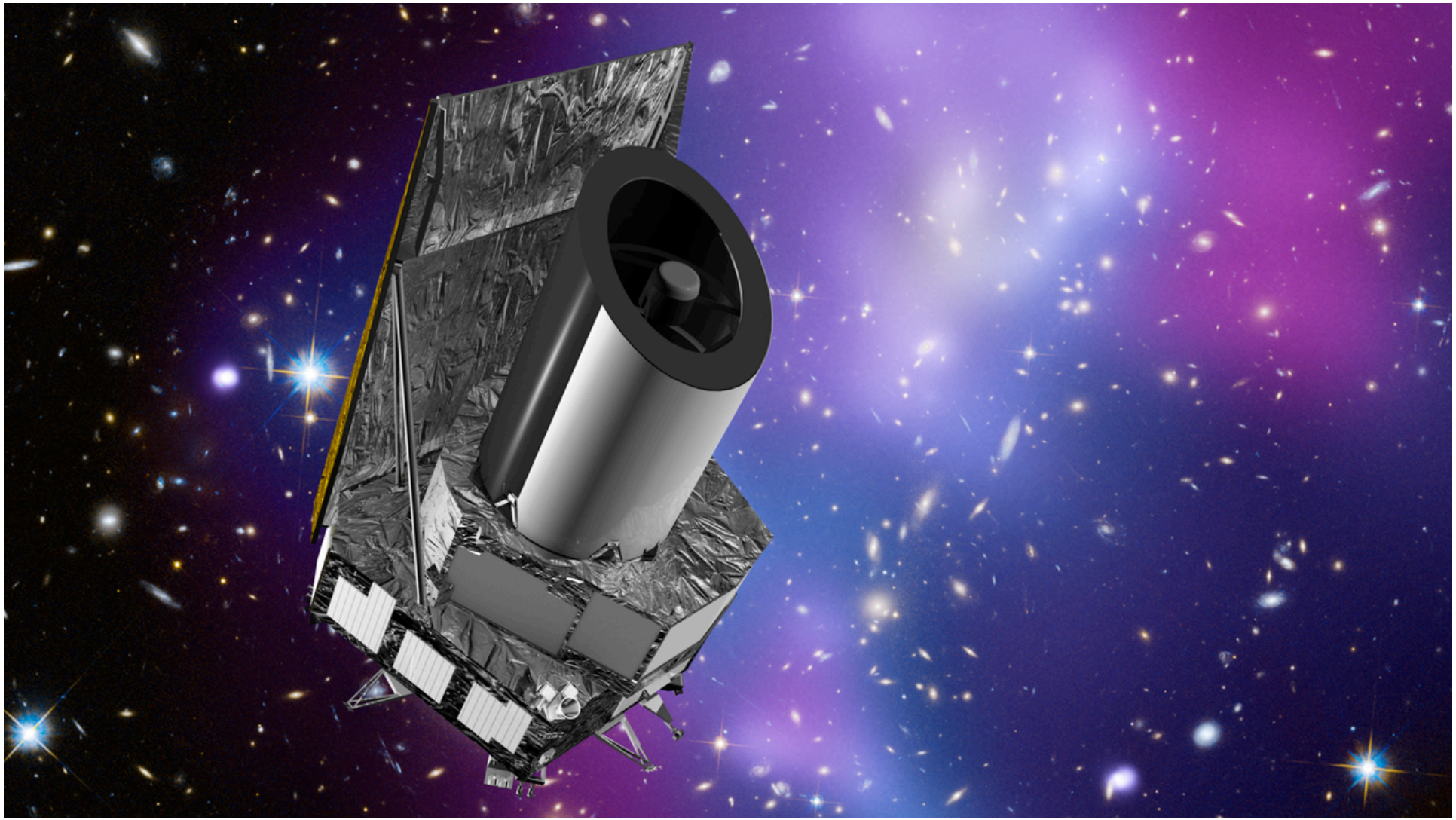
Bepi Colombo

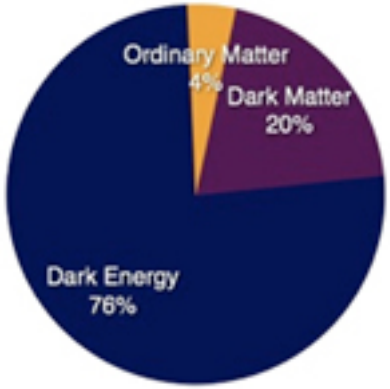
- Bepi is ESA's mission to Mercury
- Launch is in October 2018, arrival at Mercury ~ late 2025
- Primary science goals are related to Mercury's properties
- Fundamental physics aspect: testing of GR
  - Radioscience experiment (MORE) to precisely track signal from Bepi to measure geodesics
  - range with an accuracy of 15 cm and range rate of 1.5 microns/s at 1000s integration time
  - Internal accelerometer to assess non-gravitational acceleration

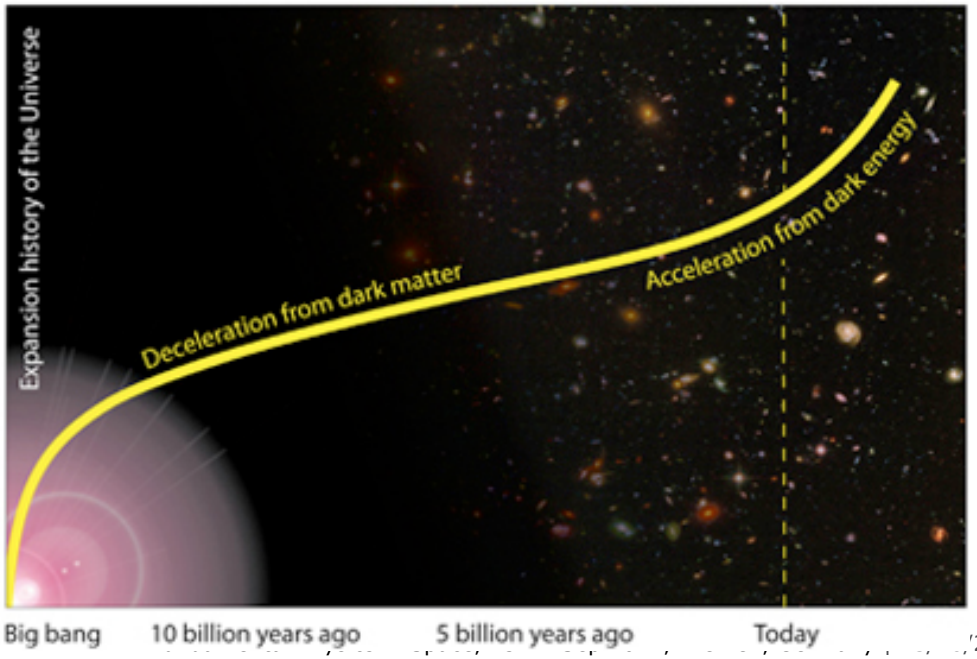


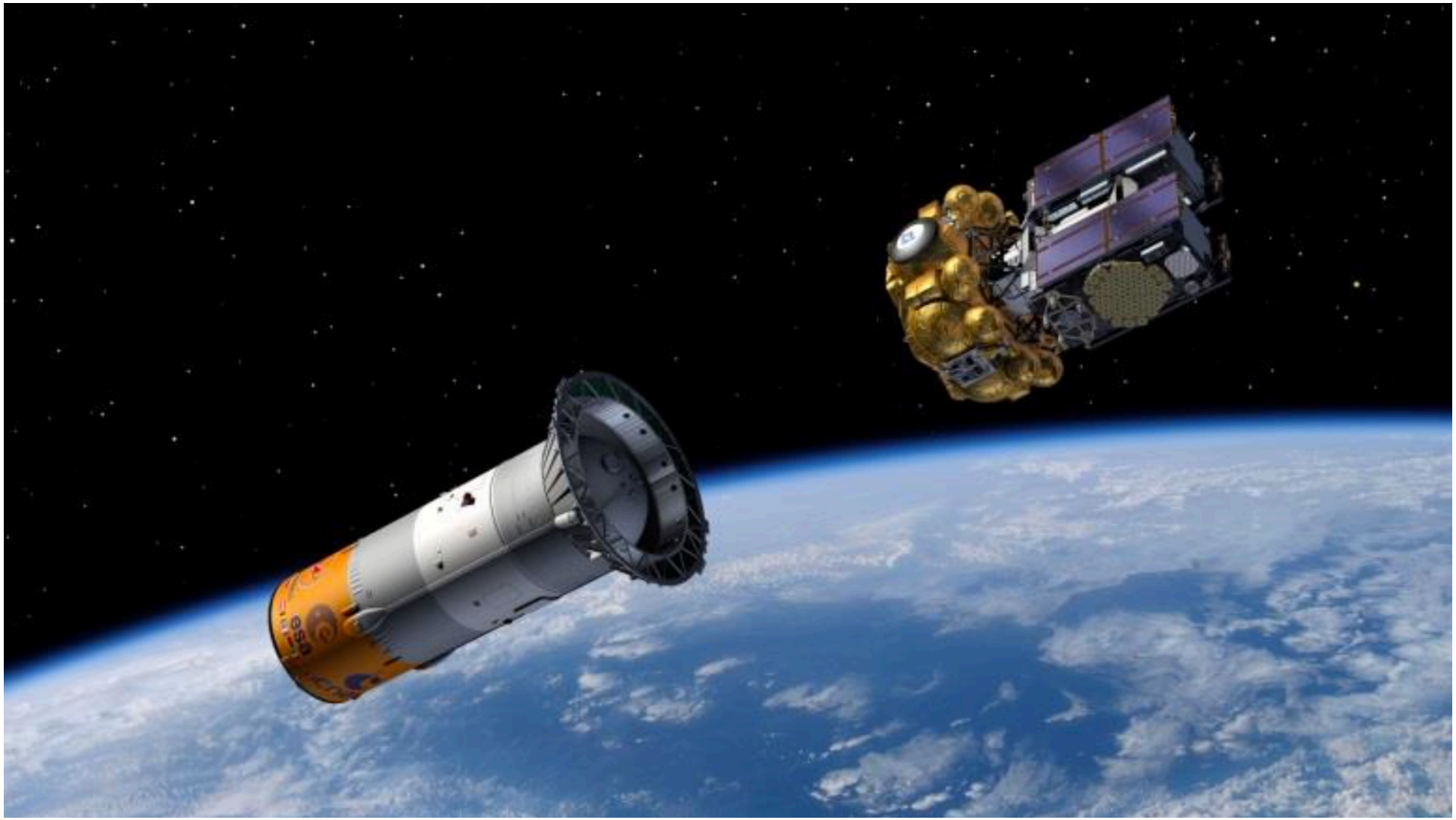


Euclid

- Euclid is an ESA mission to map the geometry of the dark Universe.
- investigate the distance-redshift relationship and the evolution of cosmic structures.
- Measure orientation of galaxies
- Launch ~2020







GREAT

Gravitational **R**edshift Test with **E**ccentric Galileo S**at**ellites

- Galileo 5&6 ended up in wrong orbit due to upper-stage anomaly
- Orbits highly eccentric, even after correction manoeuvres (e=0.15)
- Provides opportunity to test gravitational redshift
  - Current best limit from GP-A: 1.4×10^{-4}
  - Expected performance of GREAT ~ 5 times better
  - Results to be announced later this week at GNSS conference in Valencia

New Science Ideas in ESA's Science Programme

- 26 proposals received by the deadline (14 September 2016)
- No a priori technical screening.
- Scientific assessment under the responsibility of the Advisory Structure, in two stages.
- No prioritization, only identification of potentially interesting themes
- Post facto technical assessment
- Work on going on the three selected “themes”
- Results will be made public for the whole community

Selected themes – Quantum Decoherence

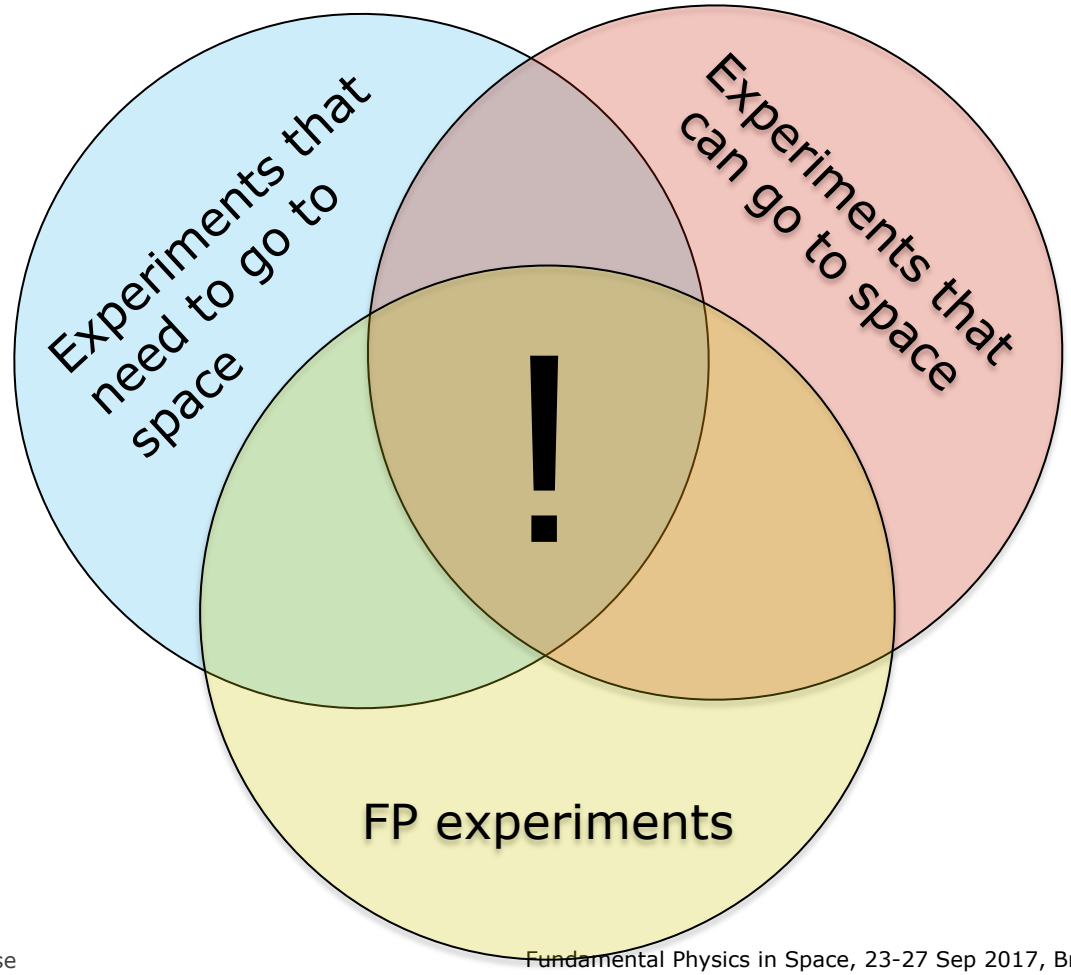
- Strong interest in quantum physics (emphasis on boundaries of quantum decoherence, connection between gravitation and quantum physics)
- Science area with potentially high impact
- Needs long, low-noise free fall -> ideally suited for LPF-like platform
- P/L, science requirements, mission definition still immature
- Workshop (Trento, 6-7 June, 2017) with proposing teams and independent experts to better understand requirements, maturity, etc., to be followed by CDF study to assess mission maturity and identify areas for enabling technology developments
- For the MAQRO proposal, see Hendrik Ulbricht's talk on Thursday

Quantum Decoherence

- Scientific lead for the preparation of the CDF identified (R. Kaltenbaek), contact point at ESA: O. Jennrich
- CDF study at ESA planned for early next year
- Primary task: Enable the community to write **competitive proposals at future calls**
  - Identify technology needs
  - Establish space engineering interface needs (mass, power, volume) for scientific payload
  - Establish environmental needs (g-loads, magnetic cleanliness, temperature, pressure, particular cleanliness, vacuum, etc.) for the experiments

Conclusion

- Currently, Fundamental Physics comprises GR and Cosmology
- Many missions in ESA have fundamental physics aspects
- Fundamental physics in the future will include fundamental quantum physics
  - Quantum decoherence
  - Fundamentals of the measurement process
  - Interaction between GR and Quantum physics
- Challenges
  - Identify experiments that **need** to go to space and **can** go to space


Experiments that need to go to space
Experiments that can go to space
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FP experiments