Geodynamical studies of planetary moons with PRIDE (Planetary Radio Interferometry and Doppler Experiment)

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Introduction

- MSc. Aerospace Engineering at Delft University of Technology, The Netherlands.
- Internship and master thesis at Joint Institute for VLBI in Europe.
- Supervisors:
  - Leonid Gurvits (JIVE)
  - Giussepe Cimo (JIVE)
  - Bert Vermeersen (TUDelft)

- **The PRIDE team**

- Lead Institute: Joint Institute for VLBI in Europe

- **Study Team:**
- Leonid Gurvits (PI), Sergei Pogrebenko, Bob Campbell, Giuseppe Cimò (JIVE)

- Imke de Pater1, Bert Vermeersenm (Delft University of Technology, The Netherlands)

- Tanja Zegers (Utrecht University, The Netherlands)

- Jürgen Oberst (Technical University Berlin and German
- Aerospace Center, Germany)

- Axel Nothnagel (University of Bonn, Germany)

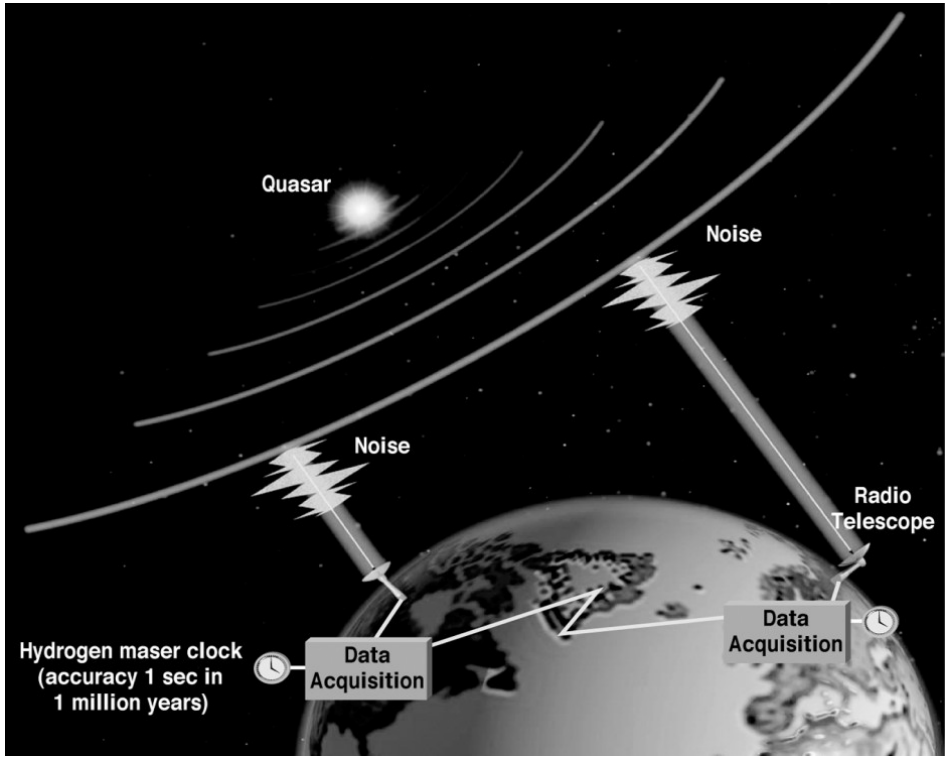
- Martin Pätzold (University of Cologne, Germany)

VLBI

Very Long Baseline Interferometry

High resolution

- Milliarcsecond on Earth
- Microarcsecond with Space VLBI



Phase Referencing

- Measurement of relative fringe phases of sources that closely spaced.
- High positional accuracy corresponding to the very high angular resolution due to the long baselines.

PRIDE: The technique

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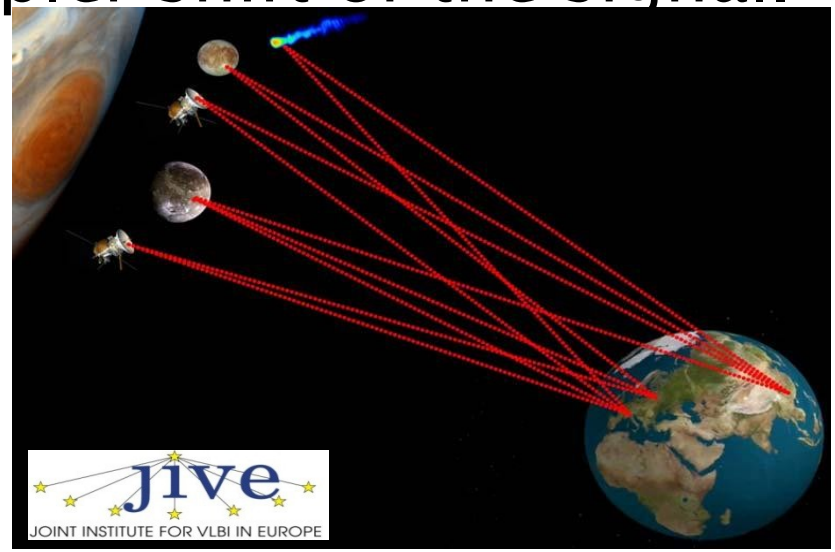
- Main focus: Detection of spacecraft's narrow band signal carrier.
- Spacecraft and calibrators signal have to be recorded in the same medium.
- End product: State-vector of spacecraft.
- By-product: Radial Doppler shift of the signal.

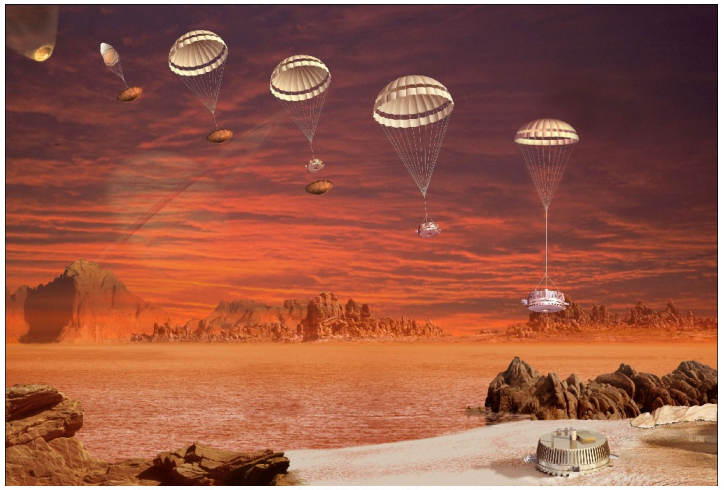


Space Science VLBI: Cassini–Huygens on Titan

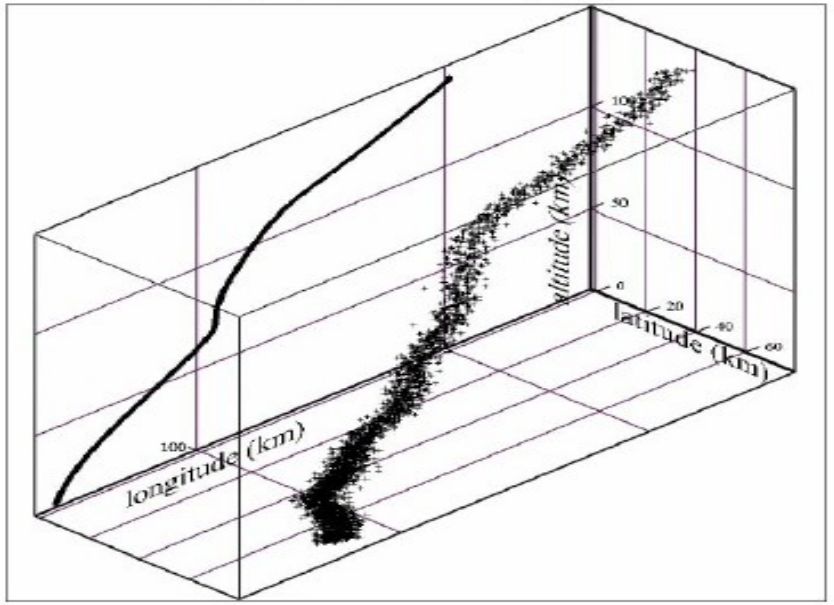
Taken from ESA

- Experiment: Acquisition of VLBI data for determining the position of Huygens probe.

At 8AU a positional accuracy of ~1 km was achieved.



In 3D (altitude from DTWG trajectory)



(Xp, Yp, Zp)

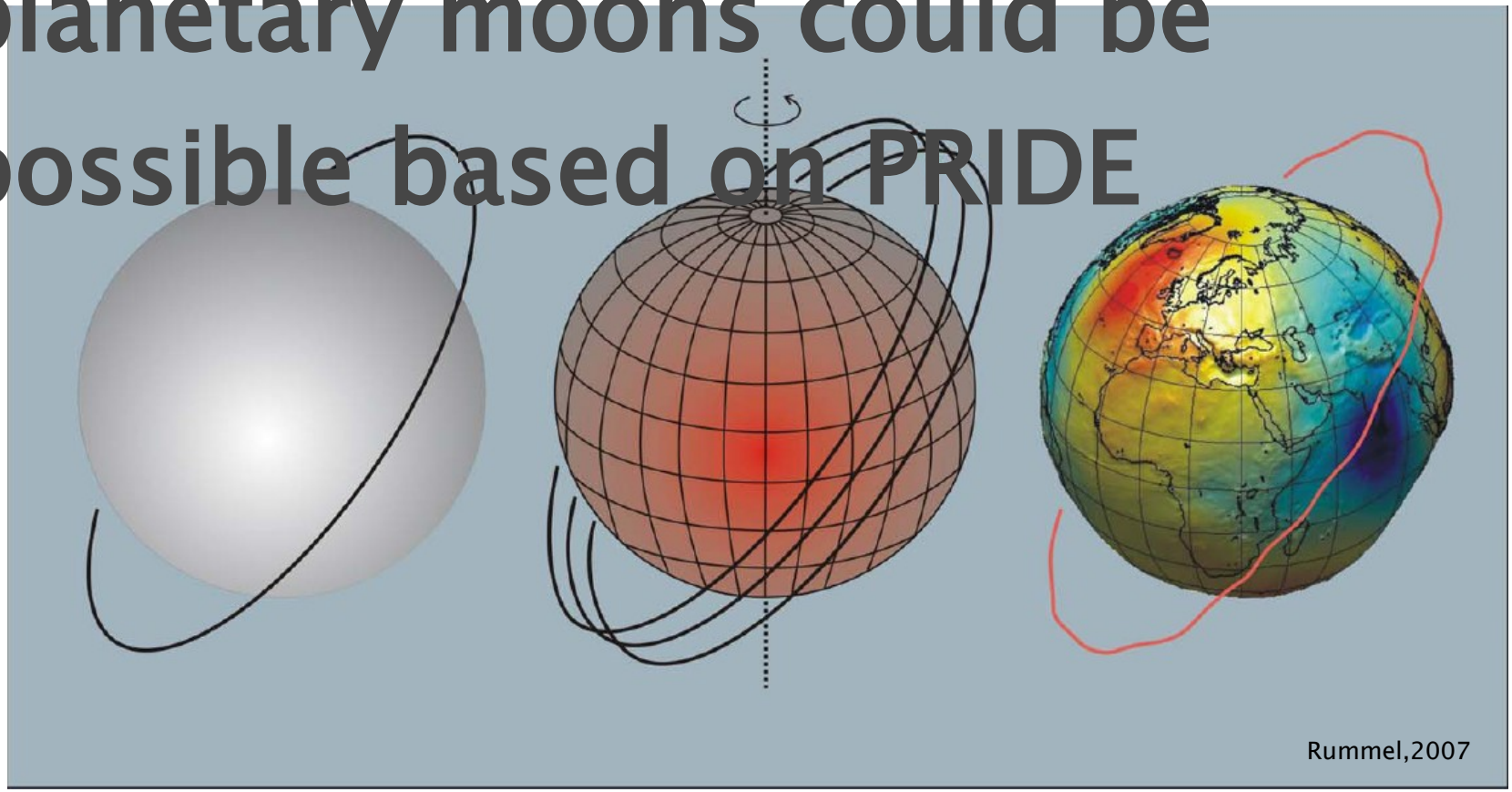
PRIDE

Planetary Radio Interferometry and Doppler Experiment

Is a multi-disciplinary enhancement of the scientific suite of current and future planetary missions.

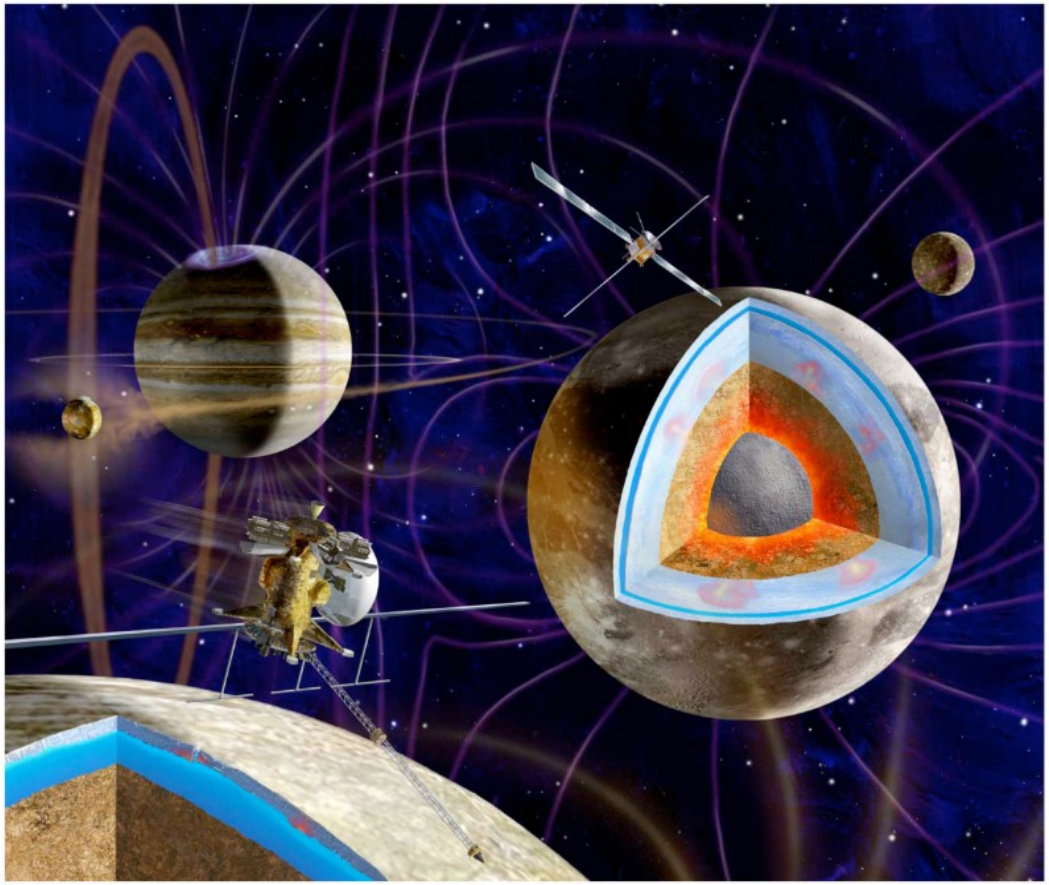
- Ultra-precise celestial mechanics of planetary systems.
- Gravimetry and geodynamics.
  - Internal structure of the moons can be obtained from analysis of topography and gravity data.

Geodynamical studies of planetary moons could be possible based on PRIDE



Future Missions

- Europa Jupiter System Mission
  - Jupiter Europa Orbiter (JEO)
  - Jupiter Ganymede Orbiter (JGO)



Artist: Michael Carroll

PRIDE Mission Requirements

- The on-board set of PRIDE instruments includes:
  - Transmitter(s) and/or transceiver(s).
  - Ultra Stable Oscillator.
  - Antenna.
- None of the above is a PRIDE-only device. However, it is essential to optimize parameters of these devices in view of their inclusion in PRIDE.
- Earth-based assets of PRIDE are:
  - Network of radio telescopes.
  - Specialized data processing center.

Optimization of PRIDE

- Optimization of the on-board radio devices for PRIDE.
- Development and test PRIDE-related data-processing algorithms
  - Impact of radio wave propagation in the interplanetary medium and Earth ionosphere on the accuracy of PRIDE.
- Formulate requirements for interface between on-board radio systems and PRIDE-specific Earth-based assets.

Conclusions

- Success of Space Science VLBI: the Huygens experiment.
- PRIDE: Planetary Radio Interferometry and Doppler Experiment is a 'free' contribution to space mission:
  - Ultra-precise celestial mechanics
  - Geodynamics, Shape and gravimetry, internal structure and composition of moons
  - Electric properties of icy satellite surfaces and their environments;
  - Fundamental physics effects.

- Close collaboration with ESA, NASA, JAXA, IKI