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Optical Analysis and Design of Space Vis/IR Telescopes and Instruments

CISAS PhD Application - Project Work Proposal

Padova, October 25th, 2019

PhD Candidate: Paolo Chioetto

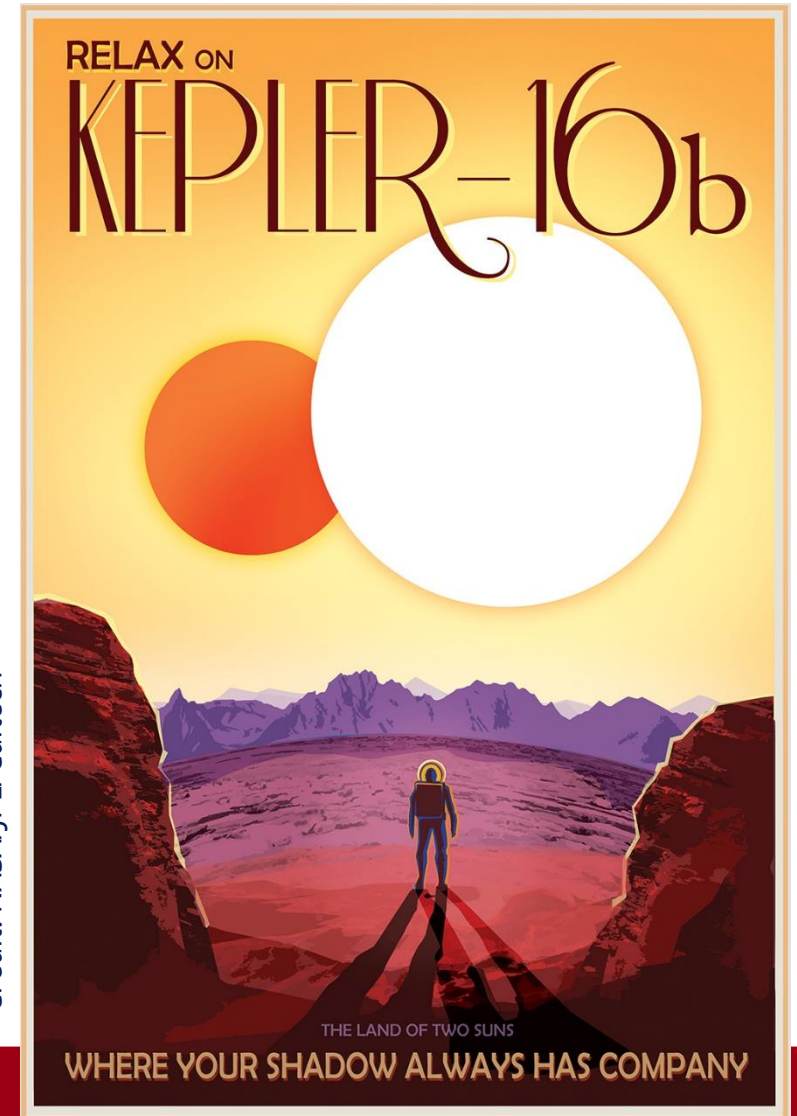
Introduction



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- Several recent and upcoming space missions employ **Visible and Near-IR Telescropy** technologies to study planetary surfaces and exoplanets
- The CNR-IFN of Padova is participating to two such missions: **ARIEL**, for Telescope and Mirrors design, and **BepiColombo**, for the Stereo Camera on the SIMBIO-SYS instrument suite
- My research proposal focuses on state-of-the-art optical analysis and design methodologies applied to the two missions



Credit: NASA/JPL/Caltech

- The Atmospheric Remote-Sensing Infrared Exoplanet Large Survey (ARIEL) is the **M4 mission** of ESA Cosmic Vision program
- It will survey of **exoplanet atmospheres** through infrared transit spectroscopy
- Two instrument modules: a **spectrometer** (1.95 – 7.8 μm), and a combined fine guidance system/visible photometer/NIR spectrometer
- The telescope and instruments will operate in cryogenic conditions ($< 50\text{ K}$)
- Launch is scheduled for 2028



Artist's rendering of the ARIEL spacecraft from Phase A (credit: ARIEL/Science Office)

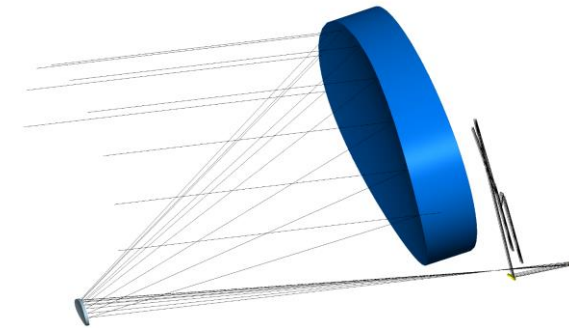
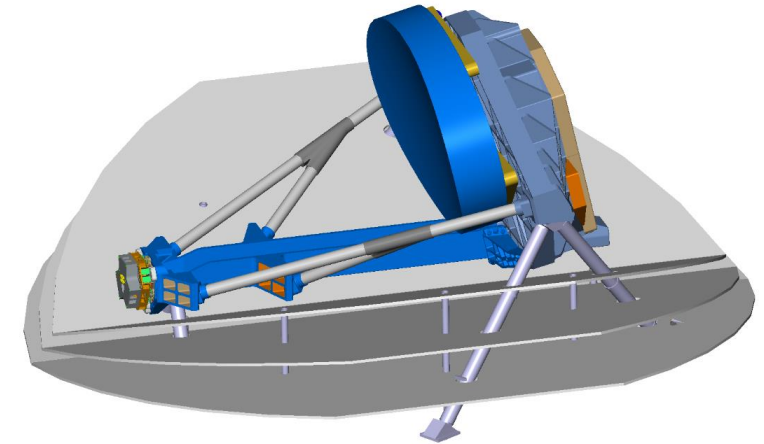
ARIEL – Telescope Optical Design



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- ARIEL Telescope: compact, unobscured off-axis Cassegrain feeding a recollimated beam to the optical bench
- Currently in Phase B1, leading to industrial partners selection. CNR-IFN is responsible for mirrors design
- Study Topics:
 - Optical Analysis
 - Performance model
 - Tolerance analysis
 - STOP Analysis



*ARIEL Telescope interim mechanical design
(above) and optical path (below)
(credit: ARIEL Consortium)*

ARIEL – Mirrors Design

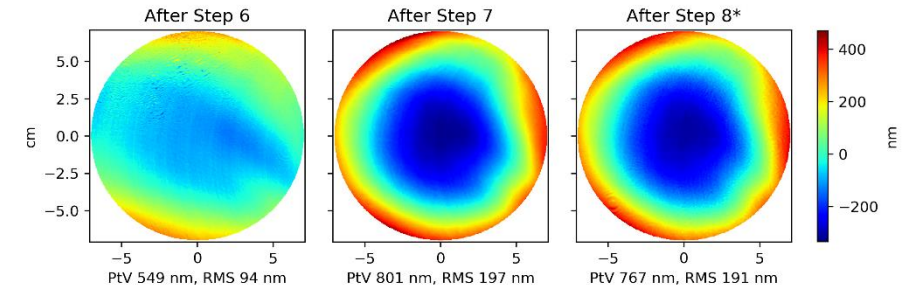


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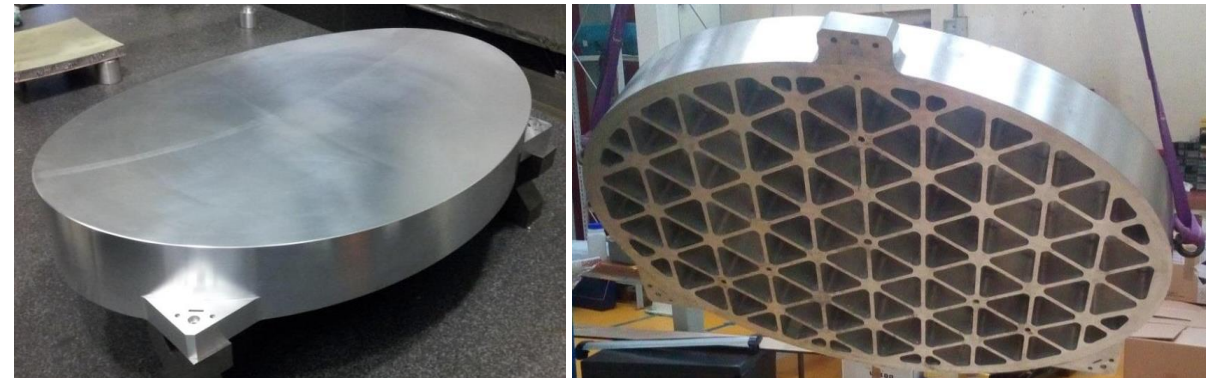


Study topics:

- Opto-mechanical stability of Al 6061-T651 and test of a stabilization procedure
- Cryo-tests on material samples and full-size demonstrator mirror for form stability
- Mirrors Surface definition and tolerance analysis
- Mirrors fabrication
- Measurements and testing
- AIV procedures



Interferometric maps of 15 cm Al flat disks after DT and thermal treatments (credit: MediaLario/P. Chioetto)



ARIEL M1 demonstrator mirror optical surface (left) and backside (right) (credit: MediaLario)

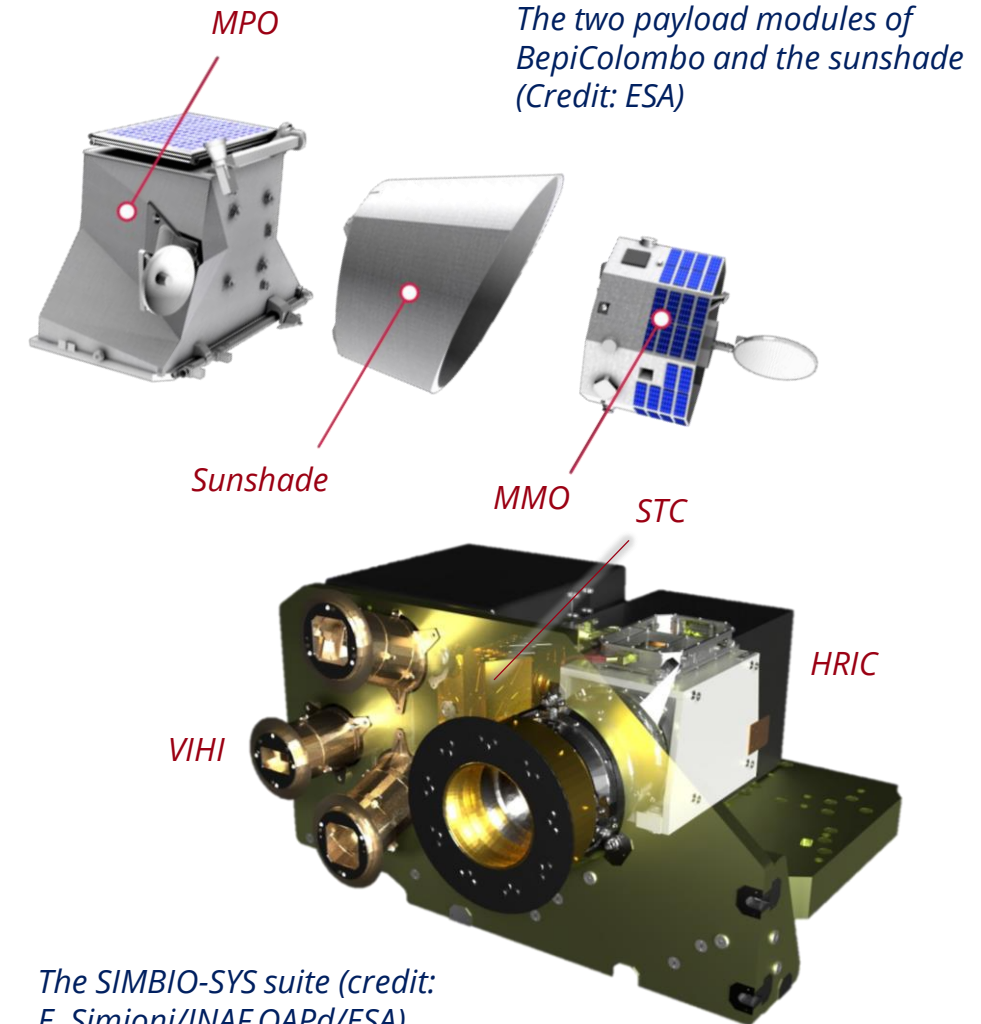
BepiColombo



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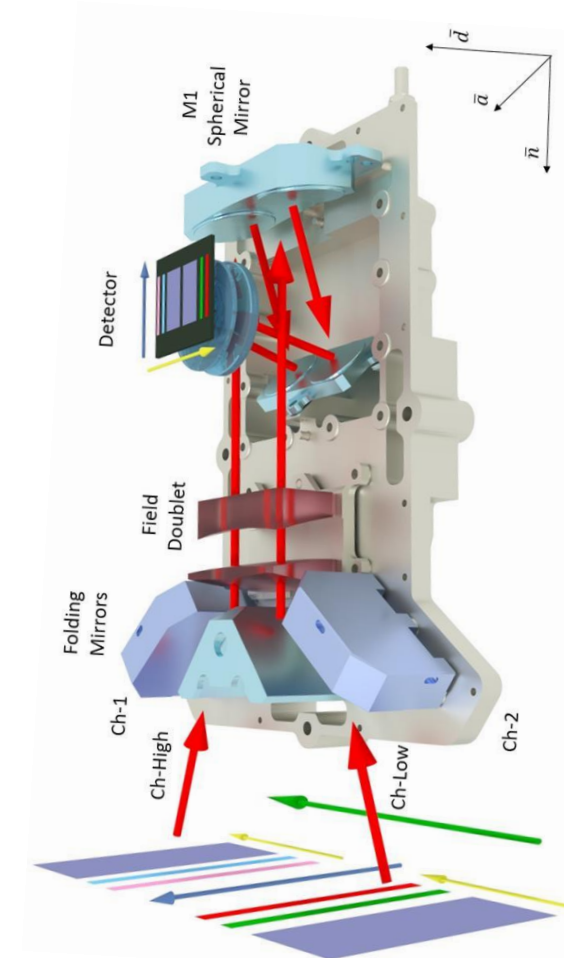


- First ESA mission to study **Mercury**
- Two payload modules: **Mercury Planet Orbiter** and Mercury Magnetospheric Orbiter
- Focus of the study: the **Stereo Camera (STC)** on the SIMBIO-SYS suite of instruments on board of the MPO
- STC will map Mercury's surface in 3D and in four different spectral bands
- Launched in 2018



Study topics:

- Optical instrument alignment analysis and geometric, radiometric and spectral calibration
- Optical tolerance analysis and its relation with stereo reconstruction capabilities
- Development of an optical instrument simulator using on-ground calibration data



*The STC optical path
(credit: E. Simioni - INAF OAPd)*

- **Project Objectives:** fulfill the scientific requirements of a technological PhD program and the specific needs of the ARIEL and BepiColombo missions.
- **Methodology:** integrate a broad range of optical analysis and design topics into a cohesive research project to advance and apply state-of-the-art methodologies and procedures in the development of optical space instrumentation.
- **Personal Objective:** mastering and improving a coherent set of competencies and methodologies to better contribute to the scientific work of the team, and to the success of the two missions.