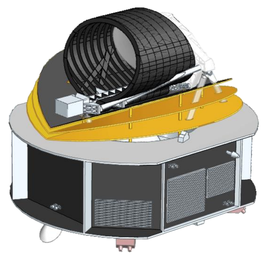

Cryogenic testing of the integrated Ariel space telescope: Design of the optical test equipment

Robert Spry*[a], Manuel Abreu[b], Keith Nowicki[a], Neil Bowles[a], Maisie Rashman[a], Cédric Pereira[b], Jake Hutchinson[a], David Miguel Ventura de Castro Alves[b], Rory Evans[a], Robert Watkins[a], Waqas Mir[a], John-Paul Walker[a], Ioannis Argyriou[c], Joss Guy[d], Juergen Schmoll[d], Chris Davison[d], Henry Eshbaugh[a], Alexandre Cabral[b], Rachel Drummond[e], Lucile Desjonqueres[e], Mark Anderson[e], Georgia Bishop[e], Paul Eccleston[e], Enzo Pascale[f], Andrew Caldwell[e], Giovanna Tinetti[g]

[a]Department of Physics, University of Oxford, UK; [b]Institute of Astrophysics an Space Sciences, University of Lisbon; [c]Institute of Astronomy, KU Leuven, Belgium; [e]STFC RAL Space Rutherford Appleton Laboratory; [f]Dipartimento di Fisica, La Sapienza Università di Roma, Italy; [g]Department of Physics and Astronomy, UCL, UK

* robert.spry@physics.ox.ac.uk; phone +44 1865272895

The Ariel Mission

- ESA's Ariel mission is a 1m class space telescope designed to observe exoplanets from L2 [1].
- Ariel will perform transit/eclipse spectroscopy to characterise exoplanet atmospheres.
- During its mission lifetime, Ariel will characterise >1000 exoplanets to enable demographic studies of atmospheres.

The Optical Ground Support Equipment (OGSE)

- The OGSE is responsible for injecting a beam into the payload for performance verification and calibration before launch Figure 1).
- The OGSE has an illumination module (Figure 2) that injects a beam into the main test chamber. A periscope within the main chamber is then used to align the OGSE output to the payload (Figure 3).

Illumination Module

- The illumination module has two optical benches. A cryogenic (70K) bench and an ambient optical bench.
- The ambient optical bench contains the light sources necessary to provide continuous coverage in the 0.5-7.8 µm range as well as an autocollimator for alignment monitoring.
- The light sources are capable of broadband as well as monochromatic illumination.
- The light sources are then fed into a vacuum chamber containing the cryogenic bench.
- An integrating sphere is then used to combine the light from the various sources. The sphere is then viewed by a series of mirrors to produce a ¼ aperture beam for injection into the payload.

Periscope Module

- A highly adjustable Z-fold assembly that sits in front of the payload.
- Used to compensate for misalignment between the illumination module and payload.

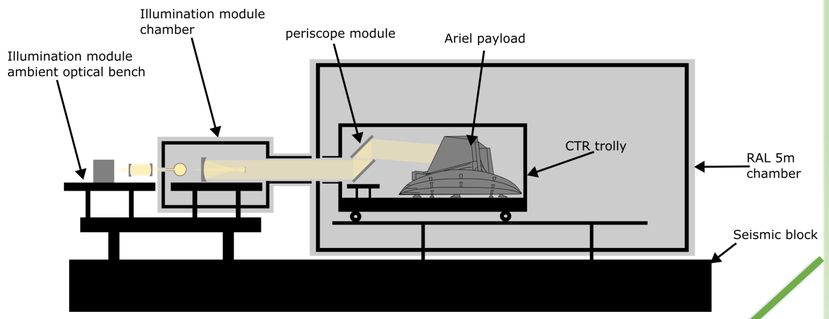

Figure 1: Test facility architecture

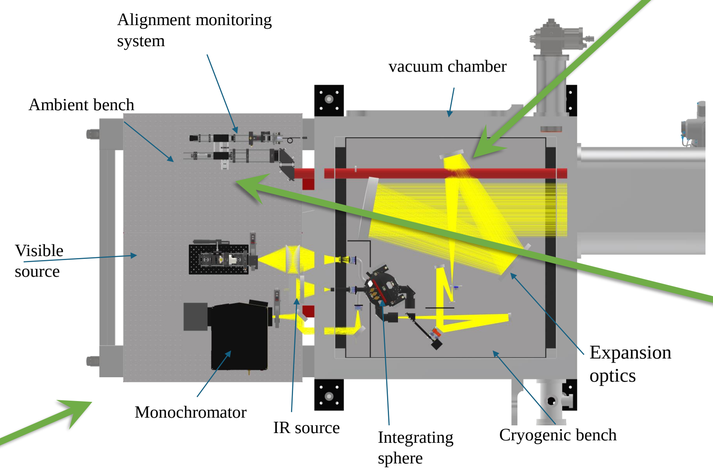

Figure 2: OGSE illumination module

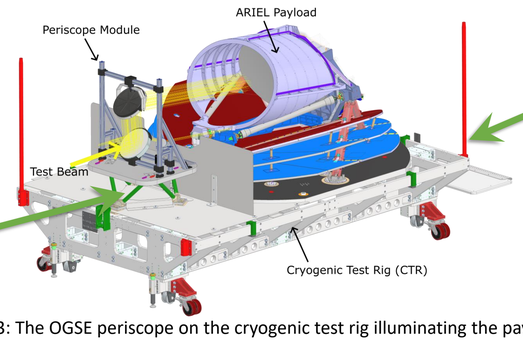

Figure 3: The OGSE periscope on the cryogenic test rig illuminating the payload.

Mechanisms for Calibration

- The ambient and cryogenic bench features a number of mechanisms to provide the illumination conditions necessary for testing of the payload.
- The OGSE uses a cryogenic flip mirror to select between two outputs of the integrating sphere. One for point source and one for extended source illumination.
- Cryogenic shutter blades at the input of the sphere are used to block/ attenuate/ filter the three input sources.
- Irises are used to enable characterisation of the payload over the full range of fluxes ARIEL plans to view.
- Cryogenic reference detectors are used to provide high stability (10s of ppm) monitoring of the output flux.
- A cryogenic voice-coil actuated beam dump provides rapid (<1s) low background (<1e/pix/s) shuttering for persistence measurements.

Alignment Monitoring System

- An autocollimator on the ambient optical bench monitors alignment drifts between the OGSE and payload.
- Information from the autocollimator is used to control a hexapod to compensate for alignment changes.
- This provides arcsecond monitoring and control.

The Cryogenic Test Rig

(from RAL Space)

- Includes a ≈40K cold shroud to enclose the ARIEL payload and OGSE Periscope.
- The interface plate with the payload can be varied in temperature (215-293K) to enable thermal balance testing.

References

[1] *E. Pascale, P. Eccleston and G. Tinetti, "The ARIEL Space Mission," 2018 5th IEEE International Workshop on Metrology for AeroSpace (MetroAeroSpace), 2018, pp. 31-34, doi: 10.1109/MetroAeroSpace.2018.8453588.*