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In-flight performance and calibration of the ExoMars Trace Gas Orbiter CaSSIS imager: selected results

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1. Introduction

The ESA-led ExoMars Trace Gas Orbiter (TGO) was launched to Mars on 14 March 2016 [1]. The TGO will search for signs of past and present life on Mars, investigate its geochemical environment, and search for atmospheric trace gases and their sources. The TGO carries 4 scientific instruments in order to reach these goals: this includes the orbiter's high-resolution imager, CaSSIS (Colour and Stereo Surface Imaging System). We present selected results of CaSSIS in-flight calibration measurements. A full description of the instrument can be found in [2]. A detailed on-ground calibration campaign was performed [3], and a number of calibration products were gathered and utilised as part of the in-flight calibration campaigns.

2. Results

Near-Earth Commissioning and Mid-Cruise Check-out. On 7 April 2016, CaSSIS was first switched on, post-launch. A number of measurements were carried out in order to verify and confirm the status and response of the instrument. We developed an automated method to recognise stars in CaSSIS stellar calibration images using the Astrometry.net library. Stellar angular coordinates from the 2MASS catalogue were used to refine the focal length and lens distortion model of CaSSIS. The model was applied to ∼80 images, with ∼2000 recognised stars. As a result, the CaSSIS focal length was refined to 875.93 mm. By taking into account the refined parameters, we were able to improve the map-projected colour-filter alignment, and reduce colour fringes in colour images.

Mars Capture Orbit. Upon arrival at Mars, the first images of the surface were acquired on 22 November 2016. During this time the TGO was in a ∼4-sol orbit, with an angle of travel with respect to the equator of 7°. From two apoapses of the initial Mars Capture Orbit (MCO-1), CaSSIS observed the spectrophotometric reference stars π^2 Orionis and ξ^2 Cet, respectively. The spacecraft was slewed so that the images of the stars passed across the detector through all four colour filters. From the reduction of these datasets we have derived the Point Spread Function (PSF) of the instrument and its absolute calibration. We present here preliminary results on the reference star π^2 Orionis, obtained at apoapsis on 20 November 2016 during the first orbit of the MCO-1 campaign (Figure 1). All results analysed so far indicate a narrow PSF as well as excellent linearity of the detector (Figure 2). Both properties show the great potential of the instrument for Mars surface imaging. To evaluate the CaSSIS signal accuracy after calibration, we used the CaSSIS Phobos image that limits the atmospheric contamination and the diversity of the surface properties observed on Mars. Several spaceborne instruments have acquired Phobos images, which can be used to compare the measured signal to the CaSSIS Phobos colour images and evaluate the biases. One of them is the Observatoire pour la Minéralogie, l'Evolution, les Glaces et l'Activité (OMEGA) hyperspectral camera on board Mars Express. The instrument provides visible (V-detector) data that covers the CaSSIS spectral range. For the comparison, the selected OMEGA image has to have close photometric geometries (i.e. phase angle) to the CaSSIS image (phase angle of 35°) to minimise the photometric effect. OMEGA observation ORBD764_0 was selected for the study (phase angle of 35°). Figure 3 presents the comparison of the OMEGA and CaSSIS disc-integrated I/F reflectances at each CaSSIS filter. We note that the deviation from the OMEGA disc-integrated I/F reflectance is equal to 0% for the BLU and PAN filters. A deviation of 10% and 6.7% is observed for the RED and the NIR filters, respectively. However, these deviations can be explained by the extrapolation of OMEGA I/F reflectances made at high wavelengths to correct the OMEGA calibration issues.

This result shows the great potential of the instrument for Mars surface colour imaging.

CaSSIS data continues to provide compelling support for the instrument's scientific ability. The now 74°-inclined orbit of the TGO means that it rotates through all local times of day several times per Mars season, so CaSSIS will have the unique ability to monitor how surface processes change with time of day as well as season. As a result, CaSSIS will be able to complement existing datasets of the martian surface, significantly improve the global colour coverage, and provide support and a wider understanding of context to observations by other instruments on board the TGO.

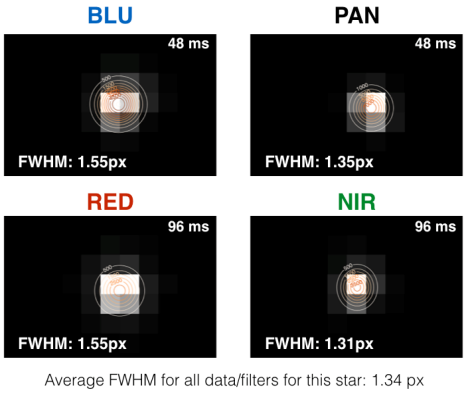

Figure 1: Images of π^2 Orionis in all four CaSSIS filters. Fitting these images with a 2D Gaussian function gives symmetric Point Spread Functions (PSF) with values of Full Width at Half Maximum (FWHM) in the range of 1.2 to 1.6 px, and an average value of 1.34 px. This indicates that the instrument is in good focus.

Acknowledgements

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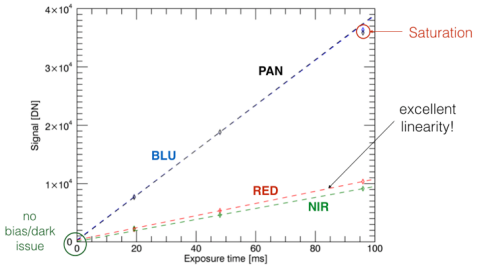

Figure 2: Plotting the integrated Point Spread Functions (PSF) intensity, as a function of the integration time, for all four colour filters shows the excellent linearity of the instrument response. This indicates that bias and dark signal behaviours are well under control, which should result in an accurate absolute calibration of the instrument.

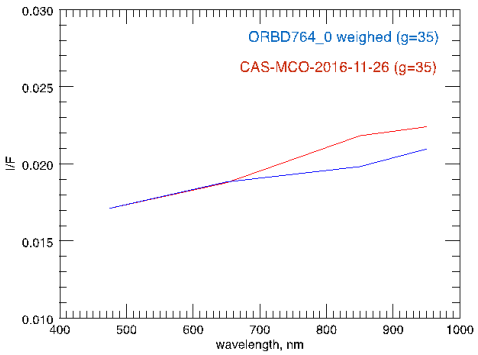

Figure 3: Comparison of the OMEGA (blue) and CaSSIS (red) Phobos disc-integrated reflectances. (BLU: centered to 475 nm, PAN: centered to 650 nm, RED: centered to 850 nm and NIR: centered to 950 nm). This result shows the great potential of the instrument for Mars surface colour imaging.

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References

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