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PlanetCam UPV-EHU visual arm characterization for solar system observations

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Abstract

PlanetCam UPV-EHU is a new astronomical camera for the observation of Solar System objects which includes two arms corresponding to the visible (VIS) and short-wave infrared (SWIR) parts of the spectrum. The visible arm of the camera is already developed allowing the study of clouds and atmospheric dynamics in Solar System planets with high resolution based on the lucky imaging technique. PlanetCam visible arm has proven suitability also for other astronomical phenomena observations such as GRBs [2], impacts, globular clusters or extrasolar planets. Here we describe PlanetCam VIS arm including its main components: sCMOS detector, filter wheels and Barlow lenses. The camera functional characteristics are also described based on the different laboratory tests performed for the precise characterisation of its radiometric and astronomic performance. Finally, a methodology for PSF characterization and absolute reflectivity I/F calibration of images is described, and some images obtained with PlanetCam visible arm presented with a brief description of the image capture and postprocessing procedures used.

1. Introduction

PlanetCam-UPV-EHU is a novel instrument designed for using the Lucky Imaging technique [4] at 1m and 2m-class telescopes. This technique has proven to be highly successful with small-sized telescopes [3] for planetary studies as shown by many works (e.g., [1]), but extending to larger apertures makes it possible to observe at deep absorption bands and at short-wavelengths where the scarce photons available compromise the technique. This is also a fast-response instrument, able to operate within a few hours from a transient phenomenon alert at 1m-class telescopes in Spain and France. The extension of PlanetCam UPV-EHU to the SWIR side of the spectrum is currently being built and commissioning is expected to be done at the beginning of 2014 second semester at Calar Alto 1,23m and 2,2m telescopes.

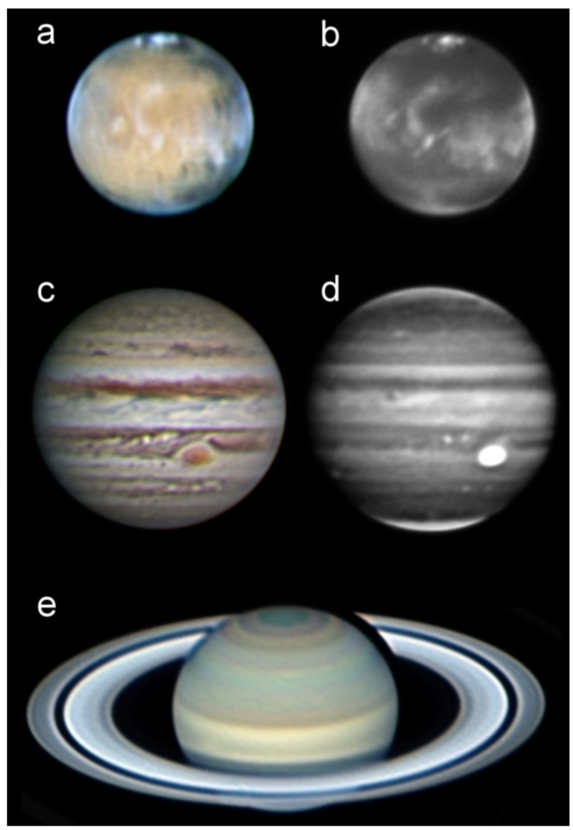

Figure 1: A show-case for some planets as seen by PlanetCam-UPV/EHU from 1,23m and 2,2m telescopes in Calar Alto (Spain) using a variety of optical configurations. in April 2014. Mars in true color (a) and at Violet (b) showing clouds and atmospheric scattering effects. Jupiter in true color (c) and at a deep methane absorption band (d). Saturn in true color displaying the Hexagon wave (e). North is up in all images.

2. Radiometric characterization

First step in the characterization of the instrument was the radiometric analysis at both laboratory facilities and using standard spectrophotometric stars while at-field testing. The spectral response of all optical elements (Barlow lenses and all 16 filters) was determined by using calibrated light sources, a monochromator and a spectrophotometer.

The quantum efficiency of the detector was also measured and found to peak at 500nm and extend up to 340nm, in a very interesting region for atmospheric studies. SCMOS linearity tests were also performed with satisfactory results.

Planetary images can be calibrated in absolute reflectivity by almost simultaneous imaging of standard stars, using a method closely following those used in previous works [5]. This provided absolute reflectivity values in good agreement with other instruments. This calibration also allows to use PlanetCam UPV-EHU to retrieve atmospheric properties by means of radiative transfer and retrieval algorithms [7].

3. Astrometry

Being a camera designed for high-resolution, diffraction-limited imaging, it is essential that PlanetCam-UPV/EHU provides an accurate enough spatial resolution all over the field of view. We have observed double stars with separations ranging from 2'' down to 0.7'', the same order as or better than the seeing at the time of the observation. Systems with equally bright stars were selected in order to test that the processing was able to resolve the system below the seeing limit. Systems with very different stars were also imaged (such as Sirius) to analyze the dynamical range provided by the camera. Some moderately populated star clusters were also used to test the distortion of the field of view, which was found to be essentially flat at intermediate amplifications (field of view of some 2º) with plate scales of 0.05''/pixel.

4. Observations and postprocessing

We have developed a custom software package able to coregister planetary observations, perform a quality analysis to select the best frames and finally stack them in order to provide a high-resolution image better than the seeing in a factor ranging from 2 to 5, depending on the observation band and the sky conditions. The software also performs all the habitual astronomical pipeline tasks. Selected images are shown in Figure 1.

Acknowledgements

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