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PlanetCam UPV/EHU: A lucky-imaging camera to study Solar System objects in the visible and near infrared

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Abstract

PlanetCam is a two-channel fast-acquisition and low-noise camera designed primarily for a multispectral study of the atmospheres of the planets (Venus, Mars, Jupiter, Saturn, Uranus and Neptune) and the satellite Titan simultaneously in optical (0.4-1 microns) and NIR (1-2.5 microns) wavelengths. Images at high temporal and spatial resolutions are acquired and processed using the "lucky imaging" technique.

1. Introduction

Planetary atmospheres of the planets (Venus, Mars, Jupiter, Saturn, Uranus and Neptune) including Saturn's satellite Titan, are highly dynamical and show a variety of phenomena at different spatial and temporal scales, ranging from hours to years, and from few kilometers to the planetary radius (2,575 km for Titan to 71,200 km for Jupiter) [1]. Of particular interest is the development of large-scale phenomena that can develop very quickly and evolve over long periods of time requiring high-resolution observations from their beginning. In recent times we have seen various events in planetary atmospheres (impacts of comets and asteroids [2-4], giant storms [5-7]) that have demonstrated the need for continuous monitoring of the planets at high resolution and good spectral coverage. Dedicated instrumentation coupled to the 1-m to 2-m class telescopes working close to diffraction limit resolution can accomplish a fast observational response to such phenomena as well as long-term studies of other features in planetary atmospheres. High spatial resolution can be achieved at low cost by means of fast imaging with video cameras and algorithms for selection of "best" individual images and stacking of them in a procedure known as "lucky imaging" that can produce images limited only by diffraction of the telescope removing the blurring effects of the atmosphere [8]. Here we present a camera concept that meets these requirements for imaging in two spectral ranges (visible or optical and near infrared) simultaneously, both of complementary interest in studies of planetary atmospheres.

2. PlanetCam UPV/EHU

PlanetCam is a two-channel camera that provides high temporal and spatial resolutions simultaneously observing in two wavelength channels: visible (0.4-1 microns) and NIR (1-2.5 microns). This is accomplished by using a dichroic beam splitter that separates both into two different optical systems and detectors. Each channel has its own set of filter wheels that includes selected broad and narrow band filters. Figure 1 shows a comprehensive scheme of the instrument. The optical channel of the camera has been built, tested and proved and it is described in what follows. Future development will include the NIR channel of the camera, currently under project. A brief outline is presented.

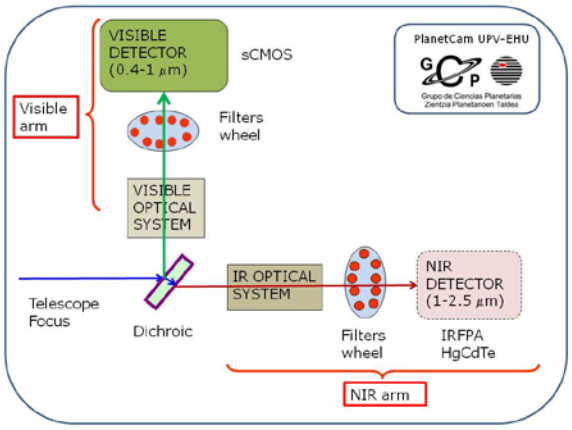

Figure 1: Scheme of PlanetCam UPV/EHU

2.1 Visible channel configuration

The focused beam from the telescope is split by a dichroic filter in two beams (VIS and NIR) at a 90º

angle. The beam-splitter is made of fused silica to guarantee a good transmission (above 90%) in the NIR channel. The 50% cut-off wavelength is close to 1000 nm, halfway between the two channel spectra coverage. It has a size of 50.8 mm to cover the whole optical beam from the telescope.

Each beam is then directed into a transfer (coupling) optics that makes the appropriate optical amplification. For the visible channel we have chosen a commercial Baader Planetarium Fluorite Flatfield Converter Barlow (BPFFC) formed by two doublets lenses (negative). The BPFFC is designed for magnifications up to 8X while the 4-element fluorite design provides a diffraction-limited, apochromatic flat field over a 90 mm image circle. The lenses are corrected from deep violet to the IR region. Two different optical configurations are possible at the telescopes in order that the full Airy disk radius covers either 3.47 pixels or 1.94 pixels depending on the telescope. The limiting field of view is 70 arc seconds.

Between the coupling lenses and the detector a double filter wheel is placed such that a total of 14filters can be used.

2.2 Visible channel detector

Since planets are bright objects we have selected for the visible channel a high-speed, mid to high sensitivity and low-noise sCMOS detector. The detector is a Neo sCMOS from ANDOR with 5.5 Mpixels (H=2560 x V=2150), pixel size 6.5 µm, working up to 100 frames per second (fps), noise of $1e^-$ at 30 fps and $4e^-$ at 100 fps, and a large dynamic range 30,000:1 at 30 fps pixel (16-bit digitization). Refrigeration is at -40ºC. The QE ranges from 37% at 400 nm to 57% (maximum) at 550 nm and descends to 5% at 1 micron.

2.3 The NIR channel

The NIR channel is still under development. The basic concept includes the use a detector covering the spectral range from 1-2.5 µm and is thought to be an HgCdTe Focal Plane Array (IRFPA) working up to 150 fps with pixel size in the range 15-30 µm.

3. Telescope Operations

PlanetCam UPV-EHU will operate at four different telescopes: (1) The Observatorio Aula Espazio Gela telescope with a diameter of 0.508 m at the ETSI-School of Engineers (UPV-EHU) in Bilbao (Spain). (2) The 1.23 m and 2.2 m telescopes of the Centro Astronómico Hispano Alemán (CAHA) at Calar Alto Observatory (Almería, Spain); (3) The 1.05 m Solar System dedicated telescope at Pic-du-Midi Observatory (France). Coupling interfaces have been built for each telescope. We report on the first results obtained during the commissioning campaigns.

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