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Planetcam UPV/EHU – A lucky imaging camera for multi-spectral observations of the Giant Planets in 0.38-1.7 μm

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Abstract

PlanetCam UPV/EHU [1] is an astronomical instrument designed for high-resolution observations of Solar System planets. The main scientific themes are atmospheric dynamics and the vertical cloud structure of Jupiter and Saturn. The instrument uses a dichroic mirror to separate the light in two beams with spectral ranges from 380 nm to 1 micron (visible channel) and from 1 to 1.7 microns (Short Wave InfraRed, SWIR channel) and two detectors working simultaneously with fast acquisition modes. High-resolution images are built using lucky imaging techniques [2]. Several hundred short exposed images are obtained and stored in fits files. Images are automatically reduced by a pipeline called PLAYLIST (written in IDL and requiring no interaction by the user) which selects the best frames and co-registers them using image correlation over several tie-points. The result is a high signal to noise ratio image that can be processed to show the faint structures in the data. PlanetCam is a visiting instrument mainly built for the 1.23 and 2.2m telescopes at Calar Alto Observatory in Spain but it has also been tested in the 1.5 m Telescope Carlos Sanchez in Tenerife and the 1.05 m Telescope at the Pic du Midi observatory.

1. Spatial resolution and filters

Each detector allows three optical configurations with spatial resolutions that can suit different atmospheric seeing conditions or observational constraints. Spatial resolution ranges from 0.03’’ to 0.23’’ per pixel in the 2.2m telescope at Calar Alto Observatory in Spain. Low luminous sources can be observed in the visible by using binning factors that sacrifice spatial resolution. Atmospheric seeing strongly affects the results and details over an extended object like Jupiter smaller than 0.4’’ are difficult to resolve in most observing runs. Smaller and bright objects like Ganymede allow attaining spatial resolutions of 0.2’’ indicating difficulties in lucky imaging with large aperture telescopes. The strength of PlanetCam, however, is the capability of obtaining high-resolution observations also in narrow band filters.

Observations are obtained in broad band visible filters and in narrow band filters in and out methane absorbing bands in the visible and near infrared. These observations allow to study and characterize the vertical cloud structure of Giant and Icy Planets. Additional filters from the blue to UV part of the spectrum complement this information and are also useful for the study of Venus and Mars clouds.

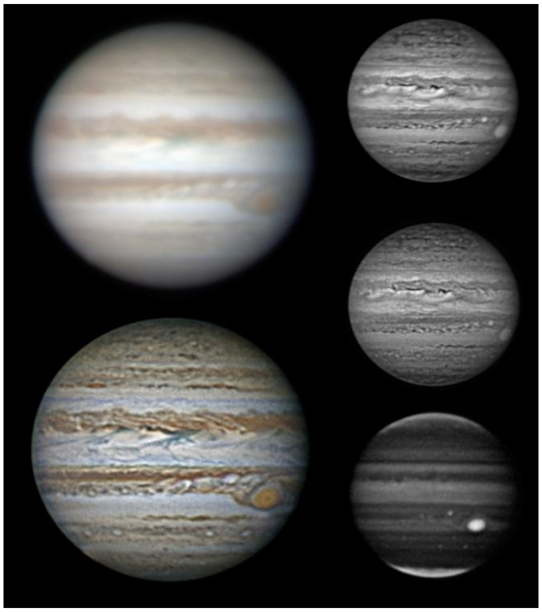

Figure 1. Jupiter. Left panel: Visible RVB color image with photometric quality (top) and after applying high-pass filters to show the high resolution data (bottom). Right panel: SWIR images in bands J, H and in a methane absorption band at 1160 nm. Observations from 11 December 2014.

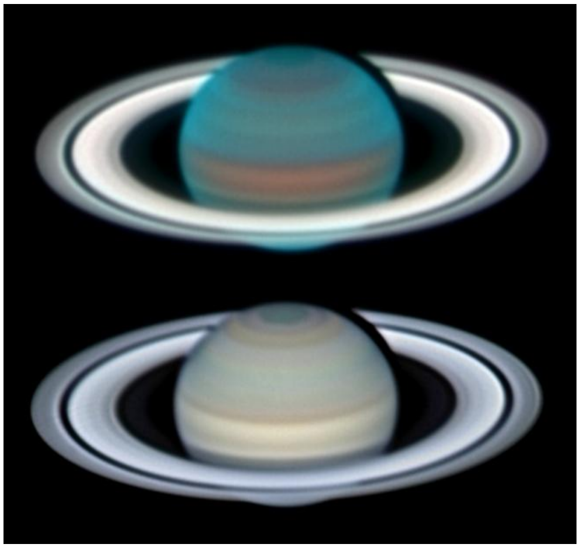

Figure 2: Saturn. Top: Upper hazes observed with a combination of a weak methane band filter, a violet and an ultraviolet filter. Bottom: Lower clouds observed in broadband RVB Johnson filters. Observations from 6 April 2014.

2. Science themes

Jupiter and Saturn observations have been obtained on the last planetary oppositions. We plan to keep observing both planets in the next few years with the next main objectives:

1- Support to Juno on Jupiter. While Jupiter will be the subject of an international broad collaboration with amateurs, PlanetCam can obtain both Visible and SWIR images of the planet.

2- Multi-spectral Ground-based observations of Saturn. Low phase angles observations complement Cassini observations of Saturn which are scarcer in the last years of the mission due to the characteristics of the orbital tour around the Saturn system. Additionally, latitudinal coverage is different from Cassini and ground-based observations.

3- Time critical phenomena. Jupiter and Saturn present dynamic atmospheres where unexpected events of large interest occasionally happen [3, 4]. Also in the event of an impact in any of these planets such as the 2009 large impact [5] or other smaller impacts [6] we can provide a quick response from Calar Alto.

In each observing night we use the rest of the hours for other scientific cases in Solar System (Venus clouds for dynamics studies, Mars, Uranus, Neptune and Titan). We also have observation runs of star occultations by asteroids and transneptunian objects as well as exoplanetary transits. In all these areas PlanetCam can provide valuable data.

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