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Astronomy

A New Photometer-Polarimeter Coupled with CCD and Spectropolarimetric Maps of the Lunar Surface

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(Presented by Academy Member George Chagelishvili)

ABSTRACT. Description of a new photometer-polarimeter coupled with CCD, applied for observations of extended celestial objects, is presented. The results of observations of four regions of the Moon surface made using this device are presented. *© 2011 Bull. Georg. Natl. Acad. Sci.*

Key words: *polarimetry, Moon surface.*

In the late 80s of the last century, after CCD had appeared, we set the problem of using CCD in polarimetric and photometric observations of extended celestial objects to increase the accuracy of measurements and space resolution of images. We developed and constructed a photometer-polarimeter coupled with CCD for the observations. The device is designed for observations on the 40-cm Zeiss refractor (F=680 cm) and the 125-cm reflector AZT-11(F=1600 cm) situated on Mt. Kanobili at the Abastumani Astrophysical Observatory [1, 2].

The optical scheme (Fig. 1) and a brief description of the device are given below. The setting of the telescope on the studied object is realized by means of the ocular (1) during the switching of the diagonal mirror (2). The scaling of the image with the coefficient 2:1 is produced by the objective (4) whose aperture ratio is 1:1.5 (F=50 mm). If necessary, there is a possibility of removing the objective (4) and then the scale totals 1:1. Polyvinyl polaroid for wavelength range λλ4000÷7500Å is used as a polarization analyzer (5). The polaroid's positional angle can be changed manually with a step of 15° at the range 0°÷360°. For photometric observations the removing of polaroid (5) from optical axis of the device is provided. The photometer-polarimeter consists of two basic parts: 1) the optical part and 2) the removable unit of CCD matrix (6) equipped with a microprocessor block (7) for the preliminary processing of data. The unit of CCD matrix works on line with personal computer (8).

As present the CCD camera SBIG ST-9X with window size 10.2×10.2 mm (512×512) is used for observations, but the device optics is designed to utilize matrices with a field up to 14×14 mm without apparently vignetting for image scaling 1:2 or 1:1.

The device has two turrets (3) with 6 positions each, allowing to work with 10 different optical filters. The turrets are turned manually. The filters in the turrets can be changed easily. The diameter of each filter is 40 mm and the diameter of the working one is 35 mm. The photometer-polarimeter device is equipped with a set of standard photometric system filters: Johnson system BVRI;

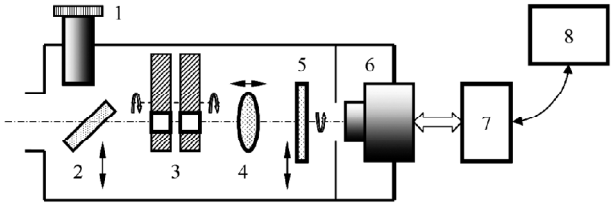

Fig.1. The optical scheme of photometer-polarimeter.

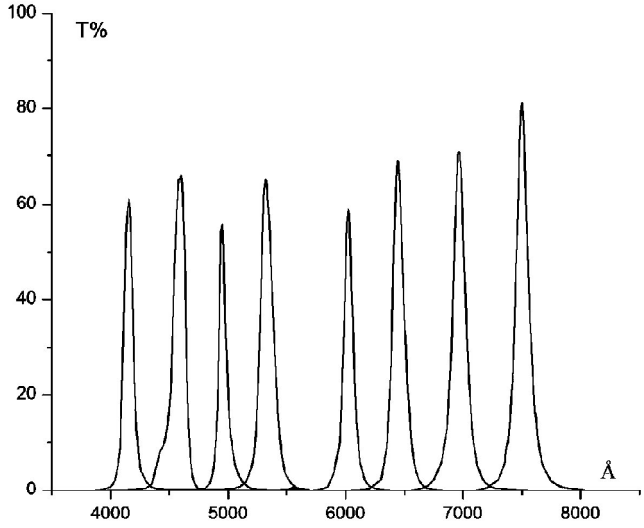

Fig. 2. Response curves of light filters.

Stromgren: v, b, y, $H_\beta 1$ (30Å), $H_\beta 2$ (150Å), as well as with the following interference optical filters: λ4155 Å (half width of the pass-band Δλ=90Å; pass-band coefficients T=61%), λ4585Å (112Å; 66%), λ4953Å (70Å; 56%), λ5325Å (120Å; 65%), λ6022Å (92Å; 82%), λ6448Å (104Å; 69%), λ6964Å (120Å; 71%), λ7500Å (λ24Å; 81%) (Fig. 2).

The optical-mechanical part of the device and other optical filters mentioned above were prepared by A. Mayer at the Laboratory of Precision Mechanics and Optics of the Abastumani Astrophysical Observatory.

Polarimetric observations of the Moon surface in different regions of the spectrum from several positions of the polaroid have been conducted on the 40 cm Zeiss refractor with CCD since 2005. Here we present some results of observations of four regions of the Moon surface. Each of them relates to 7'x7' field, when the diameter of the Moon is about 32'. So, to cover the whole surface it is necessary to get about 25 frames. These Moon surface regions are observed in six wave lengths of the visible spectra by filter parameters whose curves are presented in Fig. 2.

Work on the creation and testing of the corresponding computer programs for image processing has been done and tested. The polarimetric maps of the four regions of the lunar surface are given below (Figs. 3, 4, 5,

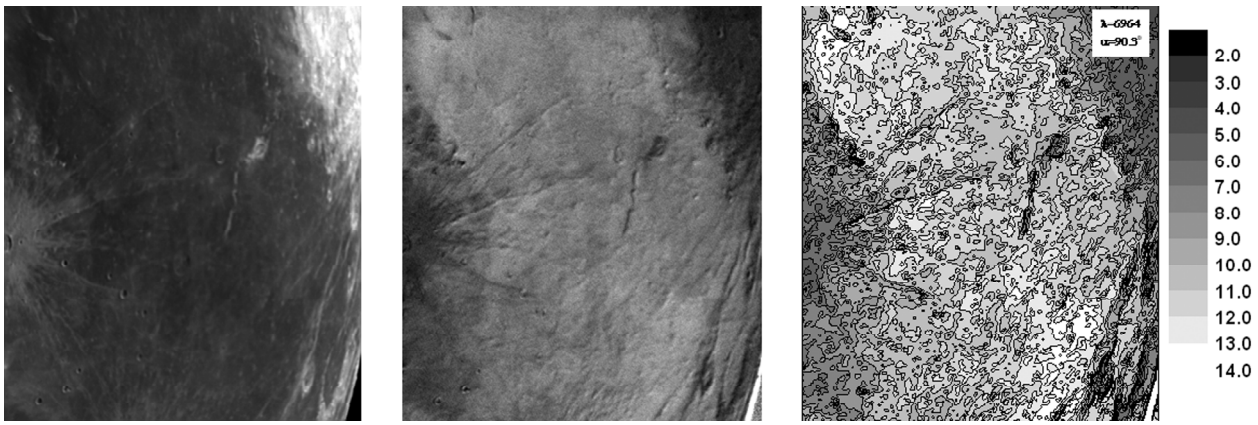

Fig. 3. Region of Reiner (λ=6964Å, α=90.3º)

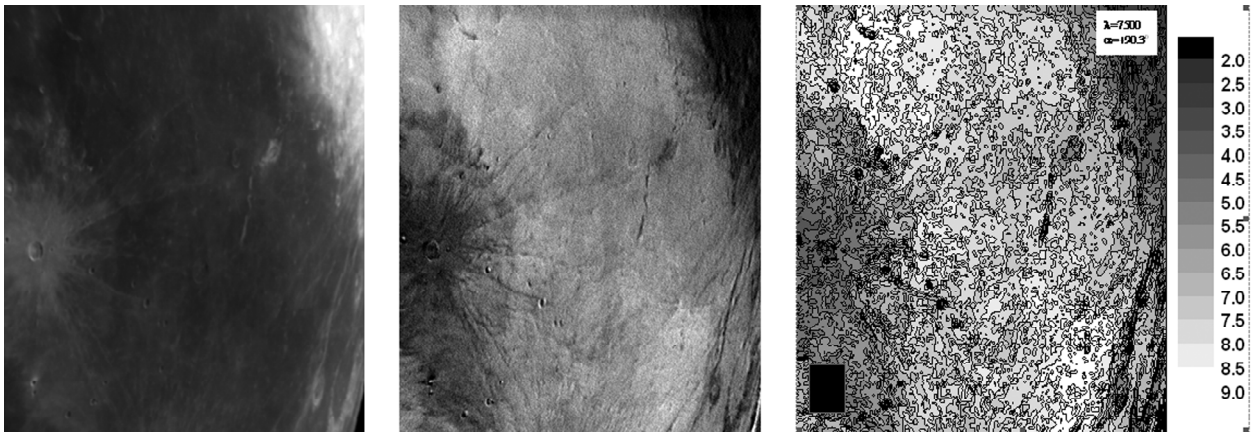

Fig. 4. Region of Reiner (λ=7500Å, α=90.2º)

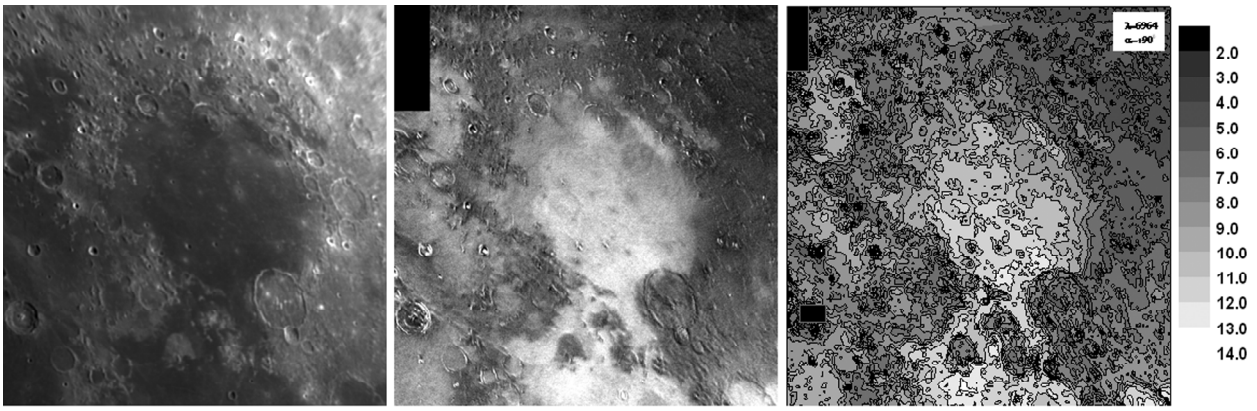

Fig. 5. Region of Mare Humorum (λ=6964Å, α=90.2º)

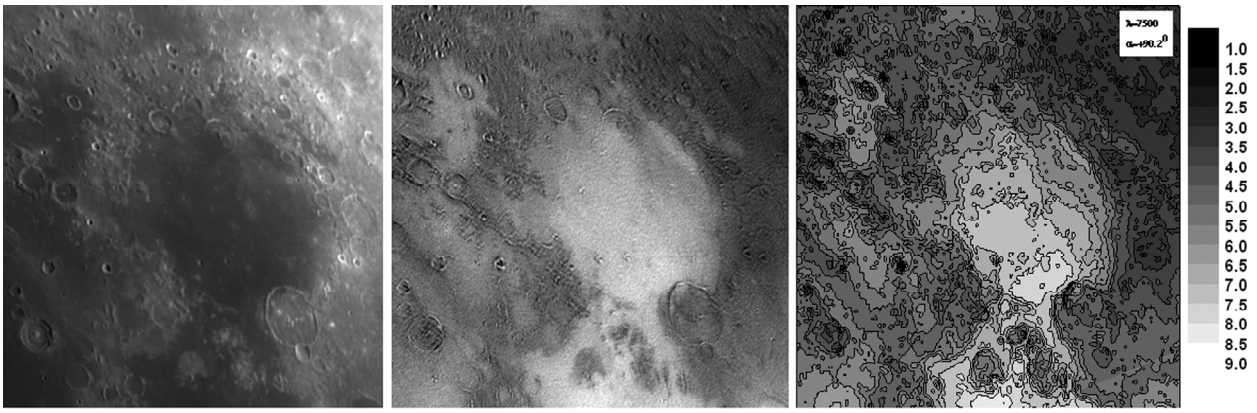

Fig. 6. Region of Mare Humorum (λ=7500Å, α=90.2º)

6). Each figure displays three frames: the left is the direct/photometric image in the given filter; the middle one – calculated polarization image (the polarization degree is calculated on the basis of the Stokes equations using photometric images in three, turned by 60 degrees, positions); right – the polarization map in isopolars. The steps of the isopolars on some images are 0.5%, on others - 1%. It should be noted that one can deduce steps up to 0.1%. The polarization maps are labeled by the observed wave length (λ) and the related angle of the Moon phase (α). The black areas on the maps relate to unauthentic values.

ასტრონომია

მთვარის ზედაპირის სპექტროპოლარიმეტრული რუკები

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მოცემულია განფენილი ციური ობიექტების დასაკვირვებლად განკუთვნილი, მუხტ-კავშირიან ხელსაწყოს ბაზაზე დამზადებული, ფოტომეტრ-პოლარიმეტრის აღწერა. მოყვანილია ამ ფოტომეტრ-პოლარიმეტრის საშუალებით მთვარის ზედაპირის ოთხი სხვადასხვა უბნის დაკვირვებათა შედეგები.

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