THE REINER GAMMA FORMATION AS CHARACTERIZED BY EARTH-BASED PHOTOMETRY AT LARGE PHASE ANGLES. N. Opanasenko and Yu. Shkuratov, Astronomical Institute of Kharkov National University. 35 Sumskaya St. Kharkov, 61022, Ukraine. opanasenko@astron.kharkov.ua

Introduction: Swirls are albedo structures, occurring on the Moon and Mercury, which are considered to be results of cometary or meteoroid swarm encounters [e.g., 1-3]. The Reiner Gamma Formation (RGF) is the best swirl example on the Moon located in the western portion of the nearside. The RGF is the most studied swirl. Infrared data obtained during lunar eclipses show the formation to have somewhat lower thermal inertia [4], indicating presence of fine-grain regolith. Radar measurements reveal no significant enhancements for the RGF area [5]. Hence, the RGF exhibits a near-surface population of stones and blocks resembling the average mare regolith layer.

The RGF shows a polarimetric anomaly at large phase angles [6], which indicates either presence of coarse-grained regolith or that the regolith is comparatively dense. The formation is generally considered to have strong forward scatter as it shows up at large phase angles near terminator, whereas craters with bright halos disappear [1,2,7]. This is generally consistent with the telescope and Clementine phase ratio images obtained for this region [8,9] at small and medium phase angles: the RGF material is characterized by lower slope of the phase function as compared to surrounding mare regions.

The purpose of this study is imaging photometry of the RGF at large phase angles when the shadow-hiding effect is the main contributor to the phase angle behavior of lunar surface brightness. This allows to make conclusions concerning the surface topography.

Source data: Photometric and polarimetric observations of the Moon were carried out with the telescope Zeis-600 of Crimean Observatory (Simeiz). A CCD LineScan Camera SONY ILX707 was used. The western portion of the lunar disk was scanned with the 2048 pixels line at the wide spectral band with λ_{eff} = 0.65 µm. Several scans of the Moon were done at the phase angles near 17°, 87°, 126°, and 134°. The spatial resolution of our data is near 2 km in the center of the lunar disk. The scan data were brought to images using complicated geometric transformations. Then for each image we compensate the brightness trends from the limb to terminator and from the poles to equator with the technique described in [10]. All images were coregistered with an original heuristic algorithm and transformed to the direct orthographic projection. Finally we mapped phase-ratios (87°/17°), (126°/87°), and (134°/126°).

Results: In Figs. 1 – 4 we present our preliminary results, respectively, for distributions of albedo at the phase angle 17° and phase-ratios (87°/17°), (126°/87°), and (134°/126°) obtained for the area that includes the RGF. This formation is clearly seen in Fig. 1 as a bright diffuse spot near the frame center. The crater Reiner is located on the right of the RGF.

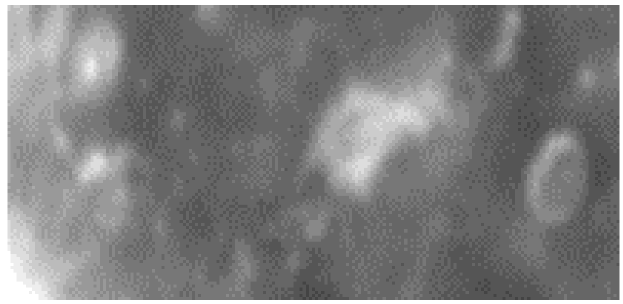

Fig. 1. Albedo image of the RGF obtained with the CCD line at 0.65 µm and phase angle 17°.

As one can see the RGF (or its portions) shows up in all the phase ratio images (see Figs. 2 – 4). The brighter the color in the phase ratio images, the smaller the slope of the phase angle curve of lunar surface brightness. The phase ratio patterns differ from the albedo one. Different portions of the RGF are characterized with slightly prominent forward scattering in the phase angle range 17° – 87°, which consists with results obtained using telescope and Clementine data [8,9]. These phase ratio features can result from smaller roughness of the RGF surface and/or higher albedo of the RGF material (high albedo implies multiple scattering that decreases the slope).

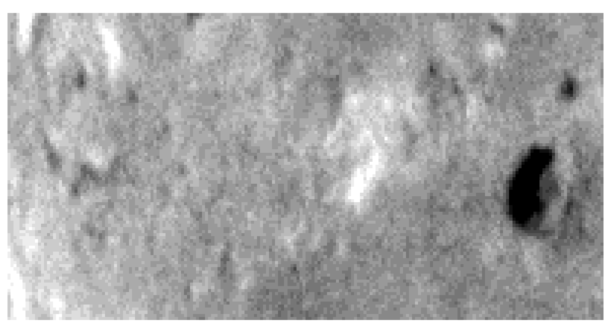

Fig. 2. A phase ratio (87°/17°) image of the RGF at 0.65 µm. Bright color corresponds to low values of the ratio.

A few local photometric anomalies in the RGF can be found in Fig. 2, which perhaps demonstrate spatial variations of topography roughness. For example, several dark spots in and around the RGF are associated with craters, their halos, and a wrinkle ridge crossing the RGF (see Fig. 5). The bright spot on the south border of the formation seen in Fig. 2 shows up as a micro-roughness anomaly; it does not match with high albedo details. Unfortunately this anomaly does not resolved on Clementine UVVIS images. Note that the amplitude of the anomaly is fairly small, <10%. Some portions of the RGF area are very similar to the adjacent mare regions in the ratio (87°/17°). This perhaps indicates the similarity of the regolith microstructure of the adjacent mare regions and the RGF portions.

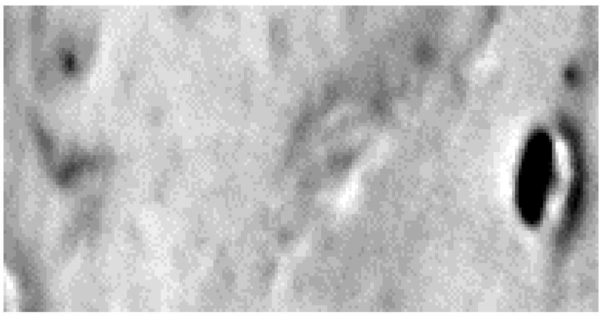

Fig. 3. A phase ratio (126°/87°) image of the RGF at 0.65 µm. Bright color corresponds to low values of the ratio.

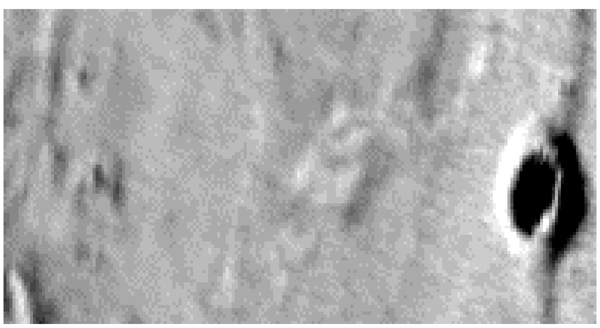

Fig. 4. A phase ratio (126°/17°) image of the RGF at 0.65 µm. Bright color corresponds to low values of the ratio.

The images of the phase ratios (126°/87°) and (134°/126°) presented, respectevely, in Figs. 3 and 4 surprisingly demonstrate higher slopes of phase curves of the RGF than those of surrounding regions. In particular, the external bright "ring" of the RGF demonstrates steeper slope of phase angle curve (and hence more rough surface) than mare vicinity (the same effect is observed for highlands). The slope difference is relatively small, <5%, but it is reliably detected. Unlike the phase ratio (87°/17°), the ratio (126°/87°) and especially the ratio (134°/126°) can be significantly effected by large scale (~ 1 – 10 m) topographies characterizing with relatively low surface slopes.

Our results clearly show that on average the RGF in the phase angle range 87° - 134° unexpectedly reveals smaller forward scattering than surroundings. This contradicts to widely believed opinion [1,2,4,7] that the RGF is a forward scatterer. The found effect is due to surface roughness; it does not compensated with the albedo influence.

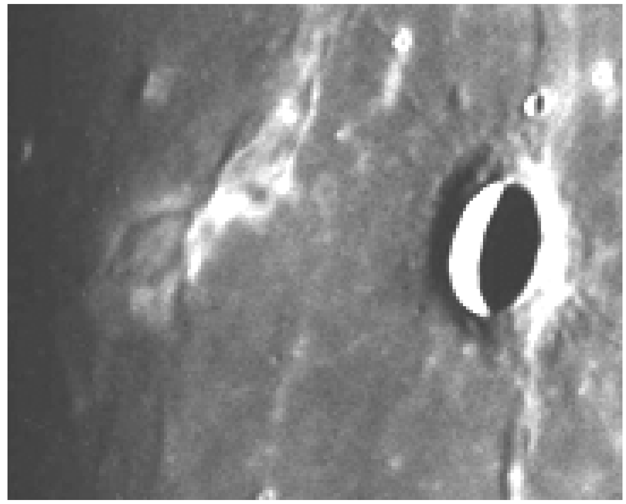

Fig. 5. An image of the RGF region acquired at terminator [11].

Conclusion: Our new telescope CCD observations demonstrate that the RGF is a slight structure anomaly, which is consistent with studies [1-3,7,12]. We do not confirm that the forward scattering effect noted in [1,2,7] on the base of observation [4] is strong. Moreover in the range 87° - 134° we have found the opposite effect. That is our observations show that at large phase angles the RGF reveals steeper phase curve than that of its mare vicinities. This indicates that the RGF surface is perhaps more rough on the scale 1 – 10 m, than the surrounding mare surface. This conclusion is in agreement with model of cometary or meteoroid swarm encounters [1-3].

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