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# Resolved Imaging Photometry of Asteroid (101955) Bennu

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## Abstract

We present photometric modeling of asteroid (101955) Bennu using resolved imagery acquired by the OSIRIS-REx mission. Image data are acquired in four color filters and one panchromatic filter. We find a phase slope for dark material on Bennu that is shallower than the global average, which may indicate less shadowing and a smoother surface. We also find evidence of phase reddening and suggest that local variations in this behavior may allow us to identify regions on the surface with more significant dust cover or surface roughness.

## 1. Introduction

The OSIRIS-REx (Origins, Spectral Interpretation, Resource Identification, Security–Regolith Explorer [3]) spacecraft arrived at its target, asteroid (101955) Bennu, in December 2018. In February 2019, OSIRIS-REx began its Detailed Survey campaign, which included global color and panchromatic imaging of Bennu. The Equatorial Stations sub-phase [3], taking place from April to June of 2019, acquires global photometric observations of Bennu. These data, combined with early data acquired during the Approach and Preliminary Survey phases, allow us to produce the first resolved photometric models of Bennu.

## 2. Image Data

The OSIRIS-REx team acquires the bulk of the photometric imaging data with MapCam, one of three specialized imagers that make up the OSIRIS-REx Camera Suite (OCAMS) [6]. MapCam has four color filters, similar to the Eight Color Asteroid Survey b, v, w, and x filters [7], and a panchromatic filter. PolyCam, the highest-resolution OCAMS camera, has a matching panchromatic filter and can share a panchromatic photometric model with MapCam. We acquired the data from Equatorial Stations at a series of phase angles corresponding to 3:20 am, 6 am, 10 am, 12:30 pm, 3 pm, 6 pm, and 8:40 pm local solar times on Bennu.

We supplement these data with images acquired during the Baseball Diamond (BBD) sub-phase [3] at 12:30 pm (MapCam and PolyCam) and 10 am (PolyCam only). Equatorial Stations observations supply similar datasets at phase angles of 7.5°, 30°, 45°, 90°, and 135° to complete our photometric coverage of the surface.

## 3. Photometric Modeling

We fit the photometric observations to six empirical photometric models: Lommel-Seeliger, ROLO, Minnaert, McEwen, and two forms of Akimov [4]. We develop preliminary photometric models using the pre-Equatorial Stations (Approach, Preliminary Survey, and BBD) data, shown in Figure 1. Complete global photometric models will be presented using Equatorial Stations data.

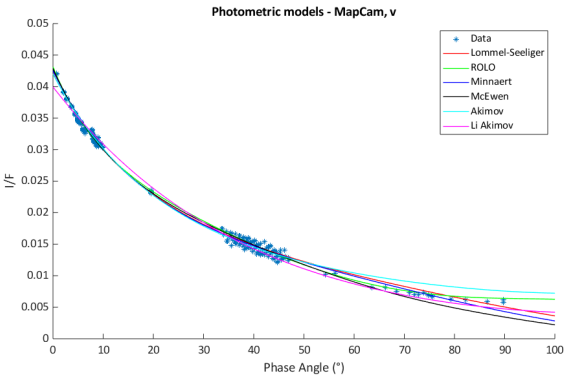


Figure 1: We fit six empirical photometric models to evaluate which best fits the data. Data points represent the disk-corrected I/F of an image. The lines represent photometric fits to these data.

## 4. Physical Implications

The results of the modeling effort will be primarily used to photometrically correct monochromatic and color index basemaps of Bennu's surface. However, some scientific conclusions can also be drawn from the modeling results directly.

The extensive dataset acquired during Equatorial Stations will also allow us to perform regional photometric analyses of regions of interest. These include potential sample sites and compositionally distinct features, such as the large dark outcrop shown in Figure 2. Bennu's global phase slope is similar to other low-albedo main-belt asteroids [2]. However, our early photometric analysis from Approach and Preliminary Survey suggested a shallower phase slope for the dark material than the global average. As darkening at high phase angles is naturally a result of shadowing, a shallower phase slope on the dark material might be indicative of less shadowing and by extension a relatively smoother surface. If true, phase slope measurements of Bennu and other asteroids might act as an indirect measure of surface roughness.

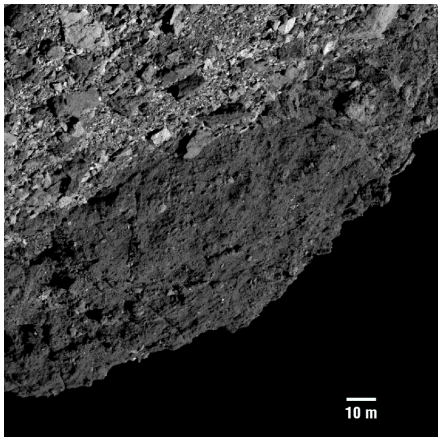


Figure 2: A Baseball Diamond image of the large dark outcrop.

Moreover, previous work with Preliminary Survey data demonstrated clear phase reddening, as shown in Figure 3 [1]. Phase reddening is typically linked to multiple-scattering surfaces, but Bennu's low albedo implies it should be dominated by single-scattering processes. Recent work on Ceres [5] suggests that phase reddening may also result from micron-scale particles or structure. Tracking this behavior as a function of location on the surface may allow us to identify regions on the surface with more significant dust cover or surface roughness.

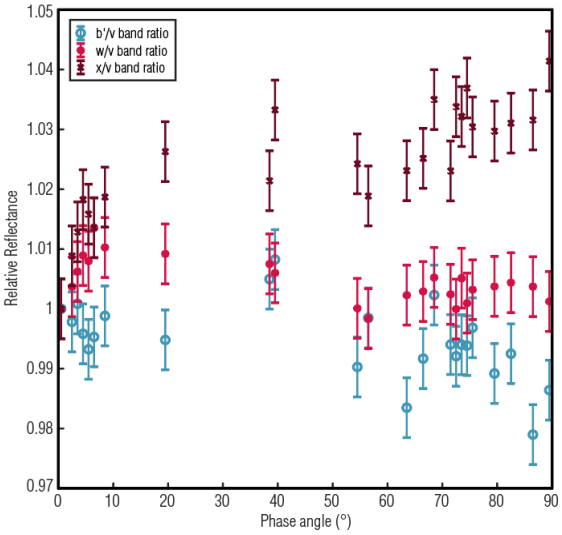


Figure 3: Early photometry from Preliminary Survey shows evidence of global phase reddening.

## Acknowledgements

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