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High-resolution Surface Structures of Asteroid Ryugu Derived from MasCam Observations

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Abstract

Using high resolution imagery from C-type asteroid Ryugu collected by MASCOT, we derive measures for surface roughness from digital image analysis.

1. Introduction

JAXA's Hayabusa2 mission arrived at C-type near Earth asteroid Ryugu in June 2018 and the on-board Mobile Asteroid Surface Scout (MASCOT) was dropped by Hayabusa2 on October 3rd, 2018 [1, 2]. MASCOT is equipped with four scientific instruments including a camera (MasCam), a radiometer (MARA), a hyperspectral microscope (MicrOmega) and a magnetometer (MasMag) aiming at investigating the surface's structure, mineralogical composition, thermal behaviour and magnetic properties [3]. After successfully settling on the surface and activating an internal mobility unit, MASCOT achieved the desired orientation for in-situ observations on the surface where it operated for 17 hours and 17 minutes during day and night time. MasCam [2] imaged the surface during day time at ambient illumination conditions and during night time using four coloured LED arrays.

1.1 MasCam Observations

During its operation on Ryugu's surface, MasCam imaged the surface at multiple occasions during day and night time [2]. MasCam uses the Scheimpflug principle and thus images from the surface of Ryugu are distorted and vary in pixel resolution starting at ~0.2 mm in the front [4]. During night time the LEDs illuminated the surface from slightly below the camera lens. A horizontal offset of the LED array introduces a shadow cast to the top right in the images (Figure 1). These shadows emphasize rough surface structures.

Figure 1: Structures of asteroid Ryugu observed by MasCam during night time illuminated with the red LED. Crumbly looking features with rough surfaces are visible. The horizontal dimension of the scenery is approximately 12 cm across.

2. Aim

The MasCam images allow the investigation of surface roughness from in-situ observations with a spatial resolution down to 0.2 mm. We use this unique data set to derive surface structural properties including the joint roughness coefficient (JRC), fractal dimension and mean slope distribution.

3. Method

We use digital image analysis techniques to extract surface roughness from the LED illuminated Ryugu surface images. Tracing along the shadows cast by the LEDs, we map the surface structures and approximate the base surface by averaging the boundary introduced by the shadows. With this information and the information on the image distortion we extract surface roughness coefficients with spatial resolutions down to 0.2 mm.

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