THE SPECTROPHOTOMETRIC PROPERTIES OF RYUGU'S REGOLITH AS SEEN AT OPPOSITION
BY THE NIRS3 ONBOARD HAYABUSA2.

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Introduction: The Near-infrared Spectrometer (NIRS3) onboard the Hayabusa2 spacecraft obtained infrared spectra of C-type asteroid 162173 Ryugu near opposition (phase angles below 1 deg.) at various spatial scales over the near-equatorial, low latitude regions (Fig 1). The data for this study includes spectra acquired prior to the first touchdown, and was binned based on footprint size. The first bin contains those spectra with footprint resolutions of 4-6 m/pixel, the second bin contains those spectra with footprint resolutions of 6-8 m/pixel, and so forth until the final bin contains those spectra with footprint resolutions of 38-40 m/pixel. Each bin was examined for phase angle coverage. Only four bins contain opposition observations: bin 4-6 m/pixel, bin 6-8 m/pixel, bin 8-10 m/pixel, and bin 38-40 m/pixel. These four bins were used for this study of the opposition surge.

Spectral Properties of the Opposition Region: Examples of the reflectance variations seen with wavelength (and footprint resolution) are shown in Figs. 2 and 3. The two wavelength examples shown are from outside the narrow 2.7 µm absorption band (at 2001.38 nm) and within the band (2701.81 nm). Note that at phase angles outside the opposition phase angle range (Fig. 3) the different wavelength data overlap, in contrast to what is observed in the opposition data (Fig. 2). The opposition region is governed by such properties as grain size and porosity within the optically active layer of the regolith, while outside of the opposition region is governed more by roughness and the physical structure (shape, cracks, inclusions,
etc.) of the grains. These observations suggest that the physical structure and roughness are constant over the size scales sampled by the different wavelengths, but that the grain size and porosity varies.

**Fig 2.** NIRS3 opposition data at 2001.38 nm (diamonds) and 2701.81 nm (circles) within the various footprint resolutions.

**Fig 3.** NIRS3 data at 2001.38 nm (diamonds) and 2701.81 nm (circles) between 14° and 16° phase

**Fig 4.** Hapke model parameter values as a function of wavelength as derived from the NIRS3 opposition data set.

**Modeling of the Opposition Data:** The NIRS3 data were modeled using the Hapke set of equations [3]. Preliminary results suggest that both the single particle scattering function and surface roughness parameters are nearly constant with wavelength, as expected. Variations with wavelength are seen in the single scattering albedo, the opposition amplitude, and the opposition width (Fig. 4).

**Comparisons with the ONC Opposition Data:** In addition to the spectral variations seen in the opposition region, which are not observed elsewhere in the NIRS3 phase curves of Ryugu, there also appears to be variations due to footprint resolution (Figs. 2 & 3). While outside the opposition region the reflectance values from each of the footprint bins overlap, this is not the case for the opposition data. The current hypothesis is that we are detecting reflectance variations across Ryugu’s surface. This implies that the grain size and porosity of the optically active layer (a few 10’s of microns deep) is not uniform across the surface.

In order to test this hypothesis, the NIRS3 data is being compared to the ONC-T opposition data [1]. Figure 1 shows that the footprints sample a variety of albedo units near the equatorial ridge. This work is ongoing and should add insight into the subtle variations in regolith properties on Ryugu’s surface.

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