Hapke Modeling of Asteroid (25143) Itokawa Using Hayabusa/AMICA Data

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Background: The JAXA's Hayabusa mission rendezvoused with Asteroid Itokawa starting from September 2005 to perform a detailed characterization of its basic properties, composition, mineralogy, geology, and returned samples from an asteroid for the first time ever. As part of an effort to map out the mineralogical composition and space weathering of the whole surface of this asteroid from multiband, high-resolution mosaic using the imaging data collected by the Asteroid Multiband Imaging Camera (AMICA), we performed a detailed photometric modeling with the Hapke model.

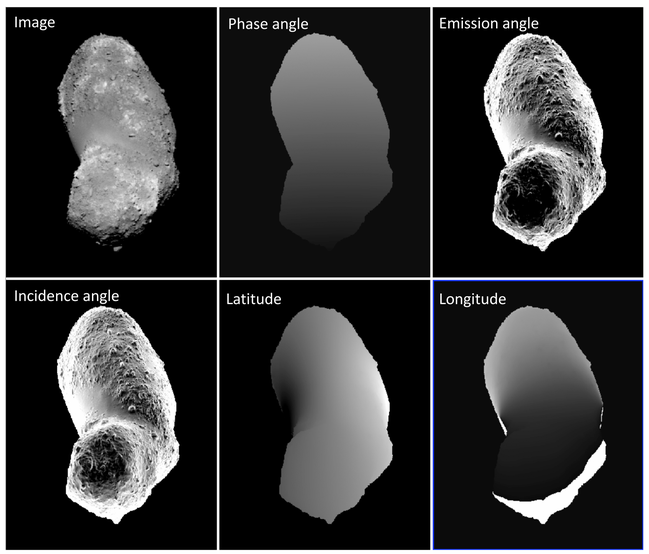

Figure 1. An example AMICA image (st_24233313252_v) and the corresponding backplanes. The image was taken on October 1, 2005 at 8 km from the asteroid center through v-band. The backplanes are calculated with the USGS ISIS using Itokawa's shape model as archived at PDS/SBN (Gaskell et al., 2008).

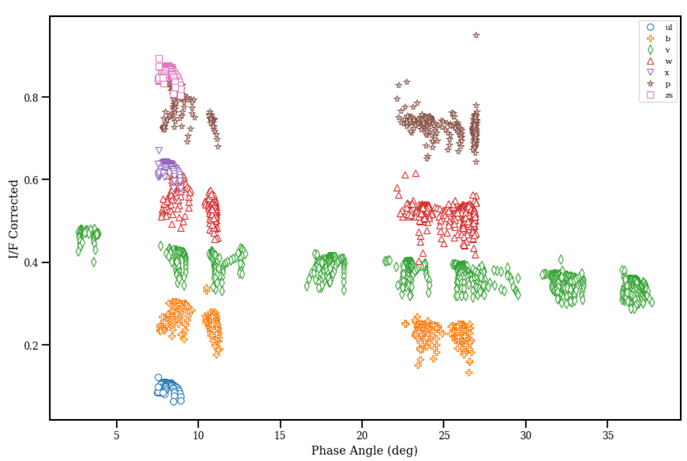

Figure 2. The I/F data and phase angle coverages through all color bands. AMICA camera is equipped with seven color filters with their names and central wavelengths as listed in Table 1. The data points plotted here are binned in (*i*, *e*, *α*) space (see Fig. 3), and corrected with a single Lommel-Seeliger model and shifted vertically for clarity. The phase angle coverage in v-band is the widest, while those in b, p, w bands are intermediate, and those in ul, x, and zs are particularly narrow between 7 deg and 9 deg. The different coverages in phase angles dictate our model fitting strategy.

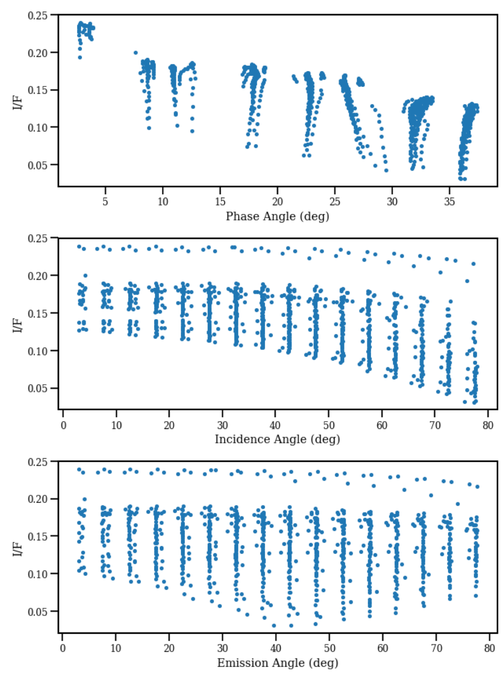

Figure 3. The v-band photometric data as an example of the data to be fitted by the Hapke model. We extract the photometric data from all pixels in all images of the same filter, then binned the data in (*i*, *e*, *α*) bins of 5 deg size, and discard all data points with *i*>80 deg or *e*>80 deg.

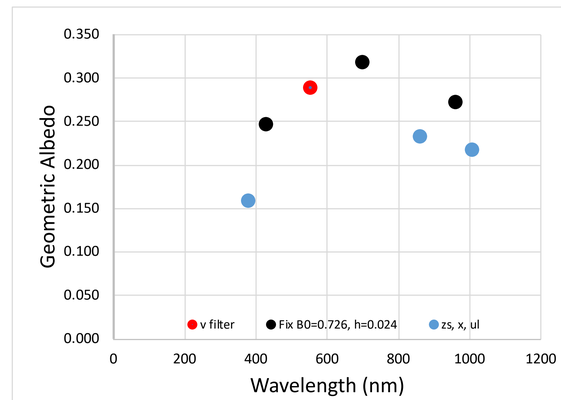

Figure 4. The geometric albedos from the best-fit Hapke parameters. We adopted a 5-parameter form of the Hapke model, with single scattering albedo (SSA), roughness, asymmetry factor g for the single-scattering phase function, and the amplitude B0 and width h of the shadow-hiding opposition effect model. We started with v-band data for its widest coverage in phase angle to fit all parameters, then fix B0 and h to fit b, w, and p band data, and finally fixed g using the nearest band values to fit ul, x, and zs band data. The results are listed in Table 1. Overall the quality of modeling is satisfactory. The model RMS is high for p band, and elevated for b and w bands. The noise in the model fitting might be attributed to residual stray light in the images.

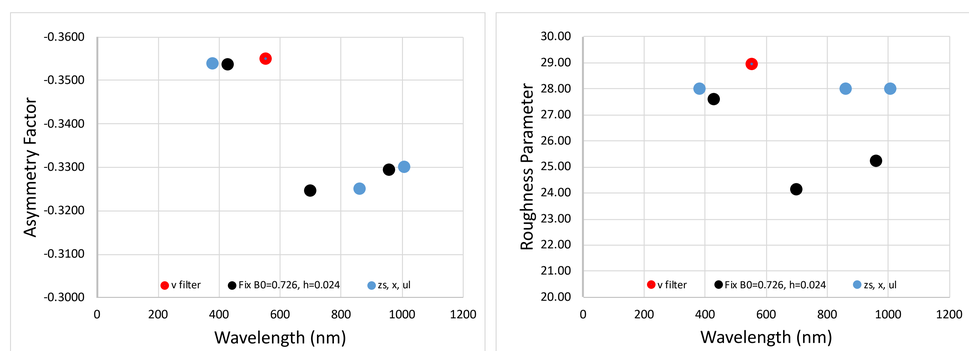

Figure 5. The best-fit asymmetry factor (left) and roughness parameter (right) for Itokawa. There might be a wavelength dependence in the phase function, with less backscattering (or more isotropic scattering) at longer wavelength, consistent with phase reddening. (Note that the values from zs, x, and ul are set fixed) The roughness does not appear to be wavelength dependent, although the scatter is quite large in the seven wavelength that we fitted, consistent with being geometric parameter and no wavelength dependence is expected. The points at 700 nm (w-band) and 960 nm (p-band) probably have large error bars given the elevated modeling RMS (Table 1).

Table 1. The modeled Hapke parameters for Itokawa derived from AMICA images.

Band	Wavelength (nm)	SSA	theta	g	B0	h	A_{geo}	A_{Bond}	RMS%
v	553	0.389	28.9	-0.35	0.73	0.024	0.29	0.12	4.5
b	429	0.336	27.6	-0.35	(0.73)	(0.024)	0.25	0.10	9.2
w	700	0.469	24.1	-0.32	(0.73)	(0.024)	0.32	0.15	9.5
p	960	0.400	25.2	-0.33	(0.73)	(0.024)	0.27	0.13	13.8
ul	381	0.22	(28)	(-0.35)	(0.73)	(0.024)	0.16	0.062	6.1
x	861	0.35	(28)	(-0.33)	(0.73)	(0.024)	0.23	0.10	4.8
zs	1008	0.32	(28)	(-0.33)	(0.73)	(0.024)	0.22	0.094	5.1

Abstract No. 1957, Tuesday, March 20, Location 339