Thermal infrared observations and thermophysical characterization of the OSIRIS-REx target asteroid (101955) Bennu

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Near-Earth asteroids (NEAs) have garnered ever-increasing attention over the past few years due to the insights they offer into Solar System formation and evolution, the potential hazard they pose, and their accessibility for both robotic and human spaceflight missions. Among the NEAs, carbonaceous asteroids hold particular interest, because they may contain clues to how the Earth got its supplies of water and organic materials, and because none has yet been studied in detail by spacecraft. (101955) Bennu is special among the NEAs in that it will not only be visited by a spacecraft, but the OSIRIS-REx mission will also return a sample of Bennu's regolith to the Earth for detailed laboratory study. We present analysis of thermal infrared photometry and spectroscopy to test the hypotheses that Bennu is carbonaceous and that its surface is covered in fine-grained (sub-cm) regolith. The Spitzer Space Telescope observed Bennu in 2007, using the Infrared Spectrograph (IRS) to obtain spectra over the wavelength range of 5.2–38 µm and images at 16 and 22 µm at 10 different longitudes, as well as the Infrared Array Camera (IRAC) to image Bennu at 3.6, 4.5, 5.8, and 8.0 µm, also at 10 different longitudes. Thermophysical analysis, assuming a spherical body with the known rotation period and spin-pole orientation, returns an effective diameter of 484±10 m, in agreement with the effective diameter calculated from the radar shape model at the orientation of the Spitzer observations (492±20 m, Nolan et al. 2013) and a visible geometric albedo of 0.046±0.005 (using $H_V = 20.51$, Hergenrother et al. 2013). Including the radar shape model in the thermal analysis, and taking surface roughness into account, yields a disk-averaged thermal inertia of 310±70 J $m^{-2}K^{-1}s^{-1/2}$, which is significantly lower than that for several other NEAs of comparable size. There may be a small variation of thermal inertia with rotational phase (±60 J $m^{-2}K^{-1}s^{-1/2}$). The spectral analysis is inconclusive in terms of surface mineralogy; the emissivity spectra have a relatively low signal-to-noise ratio and no spectral features are detected. The thermal inertia indicates average regolith grain size on the scale of several millimeters to about a centimeter. This moderate grain size is also consistent with low spectral contrast in the 7.5–20 µm spectral range. If real, the rotational variation in thermal inertia would be consistent with a change in average grain size of only about a millimeter. The thermophysical properties of Bennu's surface appear to be fairly homogeneous longitudinally. A search for a dust coma failed to detect any extended emission, putting an upper limit of about 10^6 g of dust within 4750 km of Bennu. We predict that the OSIRIS-REx spacecraft will find a low-albedo surface with abundant sub-cm sized grains, fairly evenly distributed in longitude.

References: Hergenrother, C.W. and 15 co-authors, 2013. Lightcurve, Color and Phase Function Photometry of the OSIRIS-REx Target Asteroid (101955) Bennu. Icarus 226, 663–670; Nolan, M.C., Magri, C., Howell, E.S., Benner, L.A.M., Giorgini, J.D., Hergenrother, C.W., Hudson, R.S., Lauretta, D.S., Margo, J-L., Ostro, S.J., Scheeres, D.J. 2013. Shape model and surface properties of the OSIRIS-REx target Asteroid (101955) Bennu from radar and lightcurve observations. Icarus 226, 629–640.