ALBEDO ESTIMATES AND NEAR-INFRARED REFLECTANCE SPECTROSCOPY OF NEAR EARTH ASTEROIDS 1999 HF1 AND 2005 AB. S. Kumar[1], P.S. Hardersen[2], and M.J. Gaffey,[3] [1]Department of Space Studies, Box 9008, University of North Dakota, Grand Forks, ND 58202, sanath.sathyachandran@und.nodak.edu, [2]Department of Space Studies, Room 526, Box 9008, University of North Dakota, Grand Forks, ND 58202, Hardersen@space.edu; [3]Department of Space Studies, Room 518, Box 9008, University of North Dakota, Grand Forks, ND 58202, gaffey@space.edu.

Introduction: Albedos are important physically measurable parameters of near-Earth asteroids (NEAs) which aid in constraining their size and help in interpretation of their reflectance spectra to deduce meteorite affinities and bulk minerologies. Near-infrared reflectance spectroscopy (~0.7-2.5 microns) has proved to be an invaluable tool to understand the mineralogy of asteroids. The same observations can also be used to constrain NEA albedos with heliocentric distances near 1 AU. Low albedo objects should typically show an excess of thermal infrared radiation in the 2-2.4 micron region when their heliocentric distances approach 1 AU. The excess of thermal radiation can be modeled with a range of variables to constrain their albedos [1].

Observations: The two NEAs, 1999 HF1 and 2005 AB, were observed using the SpeX near-infrared spectrograph at the NASA Infrared Telescope Facility, Mauna Kea, Hawaii, on April 20 and 21, 2005. About 60 spectra of each asteroid were collected for data reduction along with spectra of standard and solar analogue stars. Both asteroids were observed at large phase angles. Standard (i.e., extinction) stars were observed to derive nightly extinction coefficients across the entire wavelength range; solar analogue stars were observed to correct for continuum slope effects from the use of non-G2V standard stars.

Data Reduction: Standard IRAF reduction tools were used to extract the flux values at each channel for both asteroids. Standard star observations were used to model the atmospheric conditions during the time of observations to derive the extinction coefficients as a function of wavelength. These were used to correct for atmospheric absorption, which is particularly strong in the ~1.4- and ~1.9-micron regions. A similar procedure was applied to the solar analogue star. Dividing or referencing the standard star to the solar analogue removes the effects of a non-solar continuum, induced by the use of non-G2V standard stars. Figure 1 and Figure 3 show the spectra of 1999 HF1 and 2005 AB, respectively. Data reduction and analysis were done using SpecPR [2,3].

1999 HF1 and 2005 AB were observed previously as a part of the MIT-UH-IRTF joint Campaign for NEO Spectral Reconnaissance [4]. Radar observations of 2005 AB estimate the upper limit of albedo to be around 0.06 [5]. 1999 HF1 is classified as an X type object with an albedo of 0.183 [6].

Data Analysis and Interpretation:

1999 HF1. This asteroid exhibits decreasing reflectance shortward of ~1.3-microns and a relatively flat spectrum at longer wavelengths. A weak absorption feature at ~1.0-microns appears superimposed on the reddened portion of the spectrum. There also appears to be a minor increase beyond 2.4-microns, which may be due to minor thermal emission. An unpublished spectrum from [4] does not show the excess suggested in our spectrum.

The increased reflectance at longer wavelengths in our spectrum (~2% at 2.4 microns) could seemingly be attributed to thermal emission. Modeling the thermal emission was done using THERMFLX, which uses the Standard Thermal Model (STM) [7]. Figure 2 shows a fit of the 1999 HF1 average spectrum and the expected spectrum assuming a featureless asteroid for the given phase angle and heliocentric distance. The computed curve for the previously reported albedo [6] shows a satisfactory match for the observed ~2% excess. This closely matches previous observations and places the lower limit of the albedo to be 0.18.

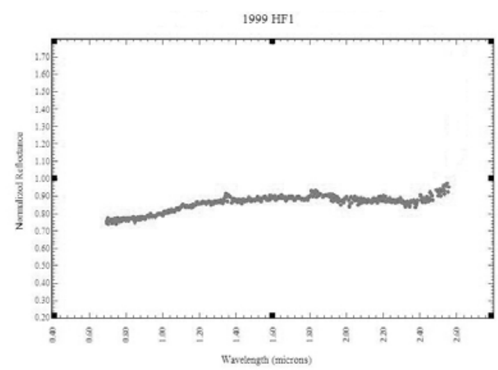

Figure 1. Average nightly reflectance spectrum of 1999 HF1.

2005 AB. This asteroid exhibits increasing reflectance in the ~0.7- to 1.2-micron region and a pronounced reflectance increase beyond 2.0-microns. Weak uncorrected telluric water vapor features are present. A spectrum of 2005 AB from [4] is similar to our spectrum. The STM was used to model the expected thermal excess using THERMFLX. Various values for the beaming parameter from 0.7 to 1.0 were used to compute the excess. A good match is seen with an assumed beaming parameter of 0.9. Application of the albedo estimation method in [1] suggests a surface reflectance of ~0.03.

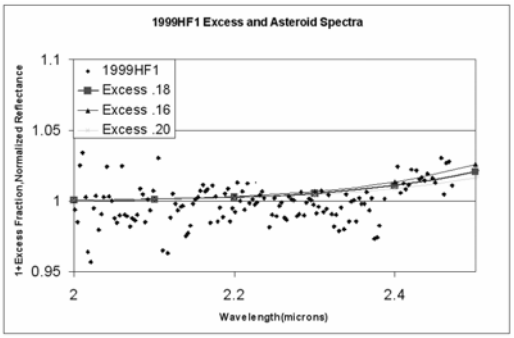

Figure 2. Modeled thermal excess superimposed on spectrum of 1999 HF1.

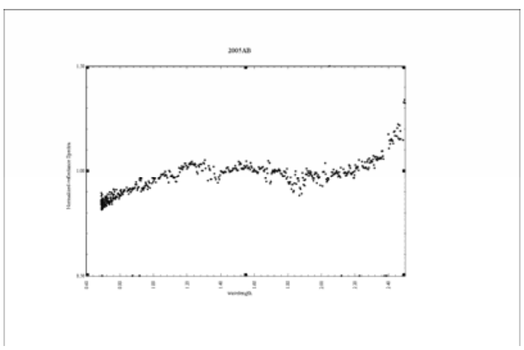

Figure 3. Average nightly reflectance spectrum for 2005 AB.

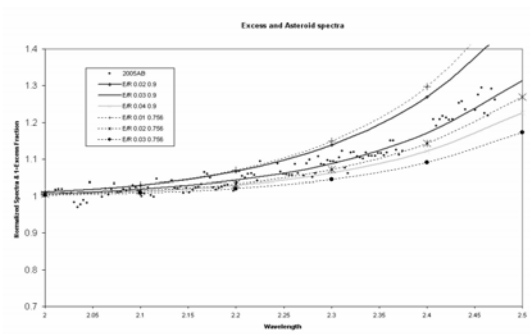

Figure 4. Modeled thermal excess superimposed on the spectrum of 2005 AB.

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References: [1] Abell P.A. (2003) Ph.D. thesis, Rensselaer Polytechnic Institute, Troy, NY. [2] Clark R.N. (1980) *PASP* 92, 221-224. [3] Gaffey M.J. (2003) *LPSC XXXIV*, Abstract #1602. [4] http://smass.mit.edu/minus.html. [5] Reddy. V. et al. (2006) *LPSC XXXVII*, this meeting. [6] Wolters, S.D. et al. (2005) *Icarus* 175, 92-110. [7] Lebofsky L.A. and Spencer J.R. (1989) in *Asteroids II*, 128-147.