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5-14 μm *Spitzer* spectra of Themis family asteroids

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Abstract

We present 5-14 μm spectra of 8 Themis family asteroids observed with *Spitzer*. The diameter and geometric albedo are determined using the NEATM model. Their emissivity spectra is studied in order to determine if they exhibit an emission plateau at about 9 to 12 μm as observed in other primitive asteroids of the outer belt, attributed to fine silicates (the Si-O stretch fundamental).

1. Introduction

The Themis family is likely the result of the breakup of a parent asteroid about 370 km in diameter ∼1 Gyr ago ([7]; [10]; [8]). The family is dominated by primitive C-type asteroids, so they can yield information about their physical and chemical conditions of their formation environment. They formed beyond the "frost line" and some fragments appear to have retained water-ice reservoirs for the age of the solar system: (1) ∼50% of it members exhibit signs of aqueous alteration (e.g. [3]); (2) water-ice was detected on the largest member of the family (24) Themis ([1], [9]). Also at least two of its members present cometary-like activity, 133P/Elst-Pizarro and 176P/LINEAR ([5]).

Our primary goal is to characterize the surface composition (and other properties such as radius, albedo and thermal inertia) of a sample of 8 Themis family asteroids observed with *Spitzer*: (222) Lucia, (223) Rosa, (316) Goberta, (383) Janina, (468) Lina, (492) Gismonda, (515) Athalia, and (526) Jena. Understanding the abundance of water-ice and hydrated minerals in this area of the solar system is particularly important, as it may be linked to the origin of Earth water.

2. *Spitzer* mid infrared spectra

Spectra were obtained with the Infrared Spectrograph (IRS) instrument on NASA *Spitzer* Space Telescope. We used two segments of the low spectral resolution mode, the SL2 (5.2 to 7.6 μm), and SL1 (7.4 to 14.2 μm). We background subtract and bad pixel mask the images, then extract spectra using the SPICE (*Spitzer* IRS Custom Extraction) software, using the default point source-tuned aperture. We scaled the SL2 spectra to match the SL1 spectra at 7.5 μm. As an example, the flux density spectrum of (515) Athalia is plotted in Fig. 1 along with the best-fit thermal model (see Sect. 3).

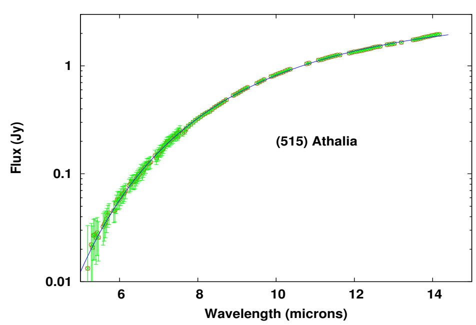

Figure 1: Flux density spectrum of (515) Ahtalia in the mid-infrared (red circles) and best-fit NEATM (blue line).

3 Thermal model

The flux from these asteroids in the 5-14μm range is dominated by thermal emission. The measured spectral energy distribution (SED) depends on the object's size, composition, and temperature distribution. We used the relatively simple near-Earth asteroid thermal model (NEATM,[4]) to fit our 5 to 13 μm spectrum. The NEATM solves simultaneously for the beaming parameter (η) and the diameter (D).

To estimate the visible geometric albedo (p_V), we adopted the values from the JPL Small-Body Database Browser (http://ssd.jpl.nasa.gov/). Using the NEATM (with bolometric emissivity 0.9) we derived D, η and p_V values presented in Table 1. As an example, the best-fit NEATM for (515) Athalia is shown in Fig. 1.

Table 1: Diameter D, albedo p_V and beaming parameter η determined using NEATM for the 8 Themis asteroids observed. Albedo uncertainties are not quoted as depend on the light curve amplitude which range from 0.1 to 0.4 mag.

object	D(km)	p_V	η
(222)	59.8±0.8	0.110	1.03±0.02
(223)	61.2±0.3	0.063	0.85±0.01
(316)	46.8±1.2	0.097	1.15±0.04
(383)	48.4±0.3	0.082	1.12±0.01
(468)	59.7±0.5	0.058	0.95±0.01
(492)	50.3±1.1	0.084	1.12±0.03
(515)	43.0±0.2	0.031	1.07±0.01
(526)	52.4±0.5	0.021	1.12±0.01

4 The emissivity spectra

The emissivity spectra of the 8 Themis family asteroids were obtained by dividing the flux density spectrum by the obtained NEATM model (see Fig. 2). The spectrum clearly exhibits an emission plateau at about 9 to 12 μm with a spectral contrast of $\sim$3-4%. This emission resembles that of silicates (the Si-O stretch fundamental).

The spectra of other primitive asteroids, three Trojan in [2] and (65) Cybele [6] also show a similar emission plateau with a highest contrast of 10 to 15% in the case of Trojans and 5% in the case of Cybele.

5. Summary and Conclusions

We present 5-14 μm spectra of 8 Themis family asteroids and derived their diameter, geometric albedo and beaming parameter using the NEATM model, and obtained their emissivity spectra. The albedo distribution

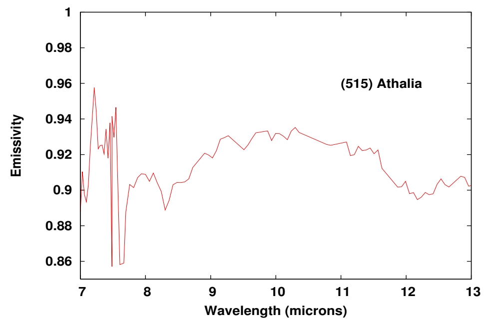

Figure 2: Emissivity spectrum of (515) Athalia. Notice the emission plateau due to fine silicate grains in the 8-12μm region. Notice also that the contrast is small ($\sim$ 3-4%)

will be discussed and compared with other primitive asteroids and in particular with two activated members of the family, 133P and 176P. The emissivity spectra of some of the asteroids observed clearly exhibits an emission plateau emission around 10 μ that resembles that of fine silicates. This results will be discussed and compared with similar structures observed in other primitive asteroids like Trojans and Cybeles.

Acknowledgements

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