Spitzer Observations of Spacecraft Target 162173 (1999 JU_3)

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Outline

I. Introduction

II. Observations and initial results

III. New constraints on surface properties

IV. Conclusions

Conclusions:

- **<u>Thermal inertia (700 $Jm^{-2}s^{-0.5}K^{-1}$) characteristic of pebble-sized surface (mm to cm), similar to asteroid 25143 Itokawa</u>**
- **Our observations rule out the low thermal inertia case allowed by previous observations**
- **Our evidence against a fine regolith is NOT very dependent on spin axis orientation**
- **Significant differences with color temperatures of Hasegawa et al. 2008, could be explained by a spin-pole orientation different from that in Abe et al. (2008)**

I. Introduction

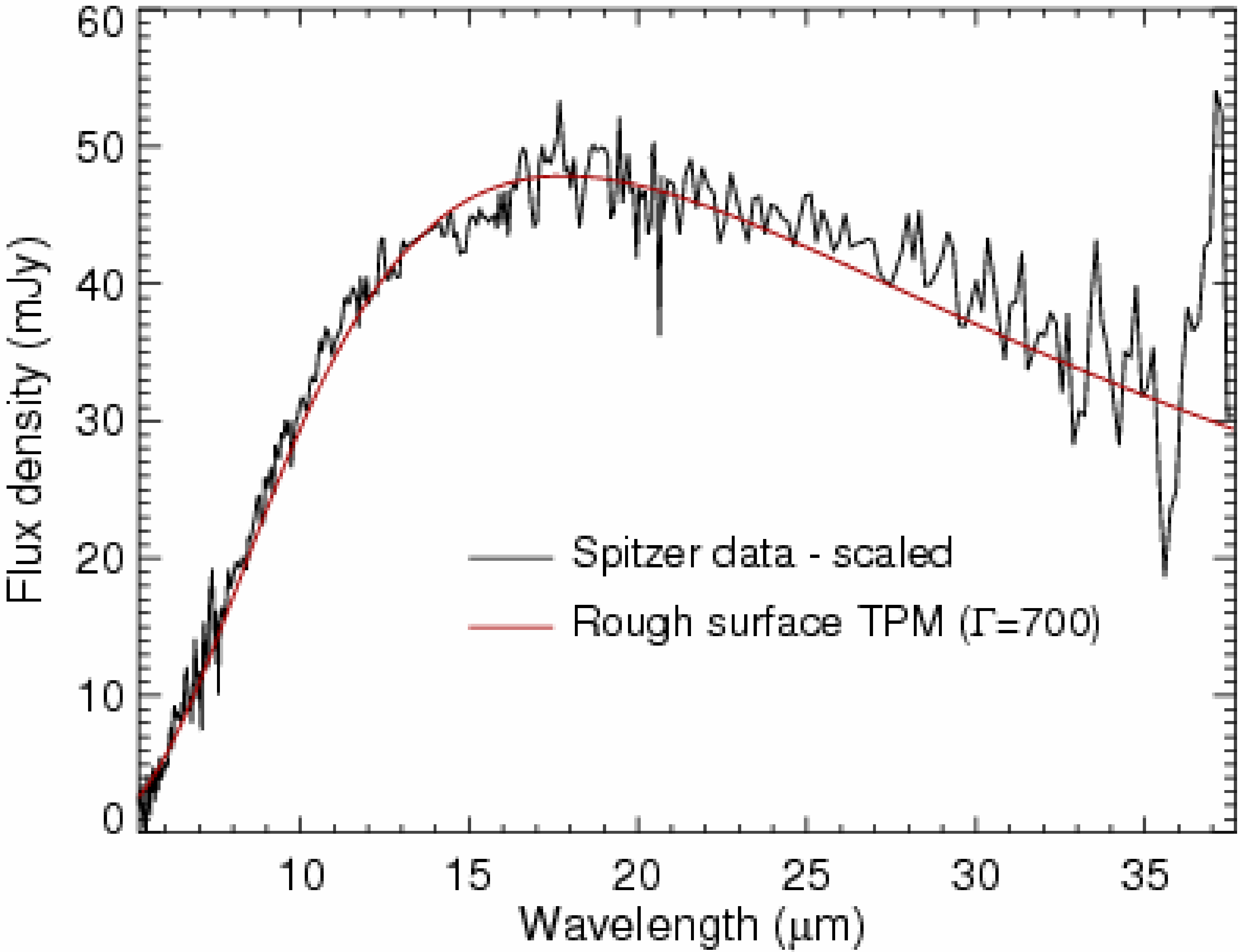
- Mid-infrared (5-38 μm) flux from asteroids is dominated by thermal emission
- Observed Spitzer spectra diagnostic of:
  - Size
  - Composition
  - **Temperature distribution**

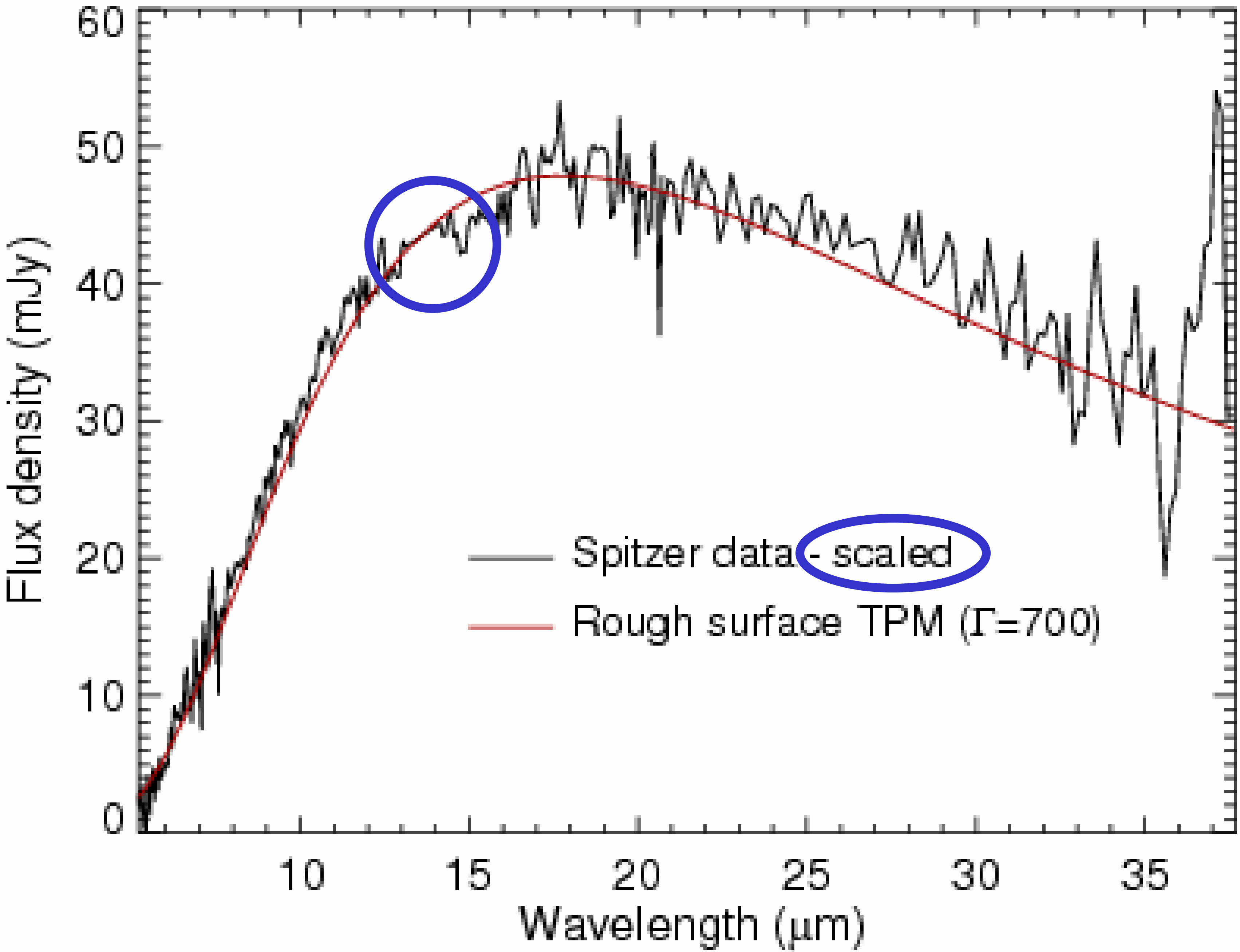
I. Introduction

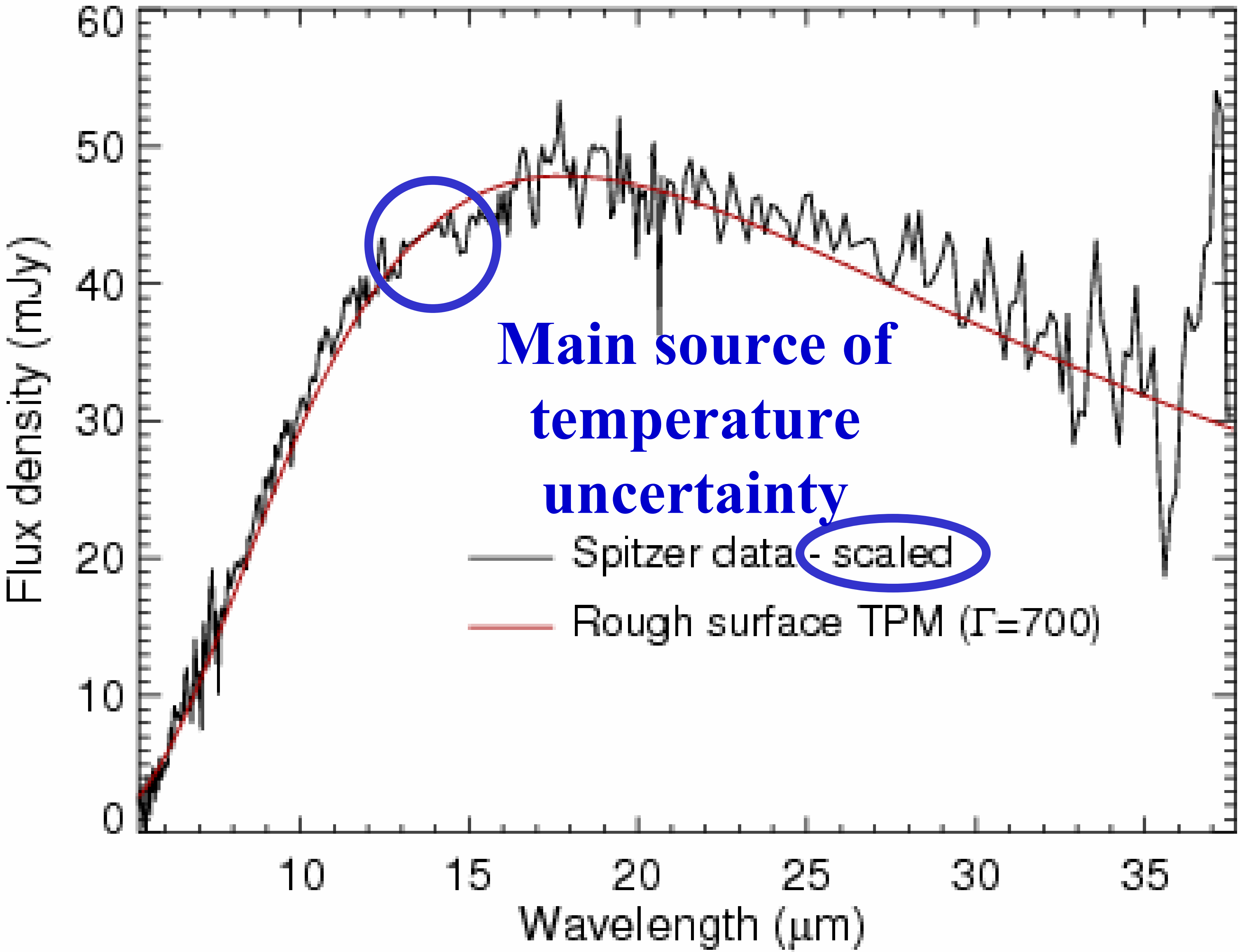
- Mid-infrared (5-38 μm) flux from asteroids is dominated by thermal emission
- Observed Spitzer spectra diagnostic of:
  - Size
  - Composition
  - **Temperature distribution**
- This last term depends on:
  - albedo
  - **thermal inertia**
  - surface roughness
  - rotation rate and **spin-pole orientation**

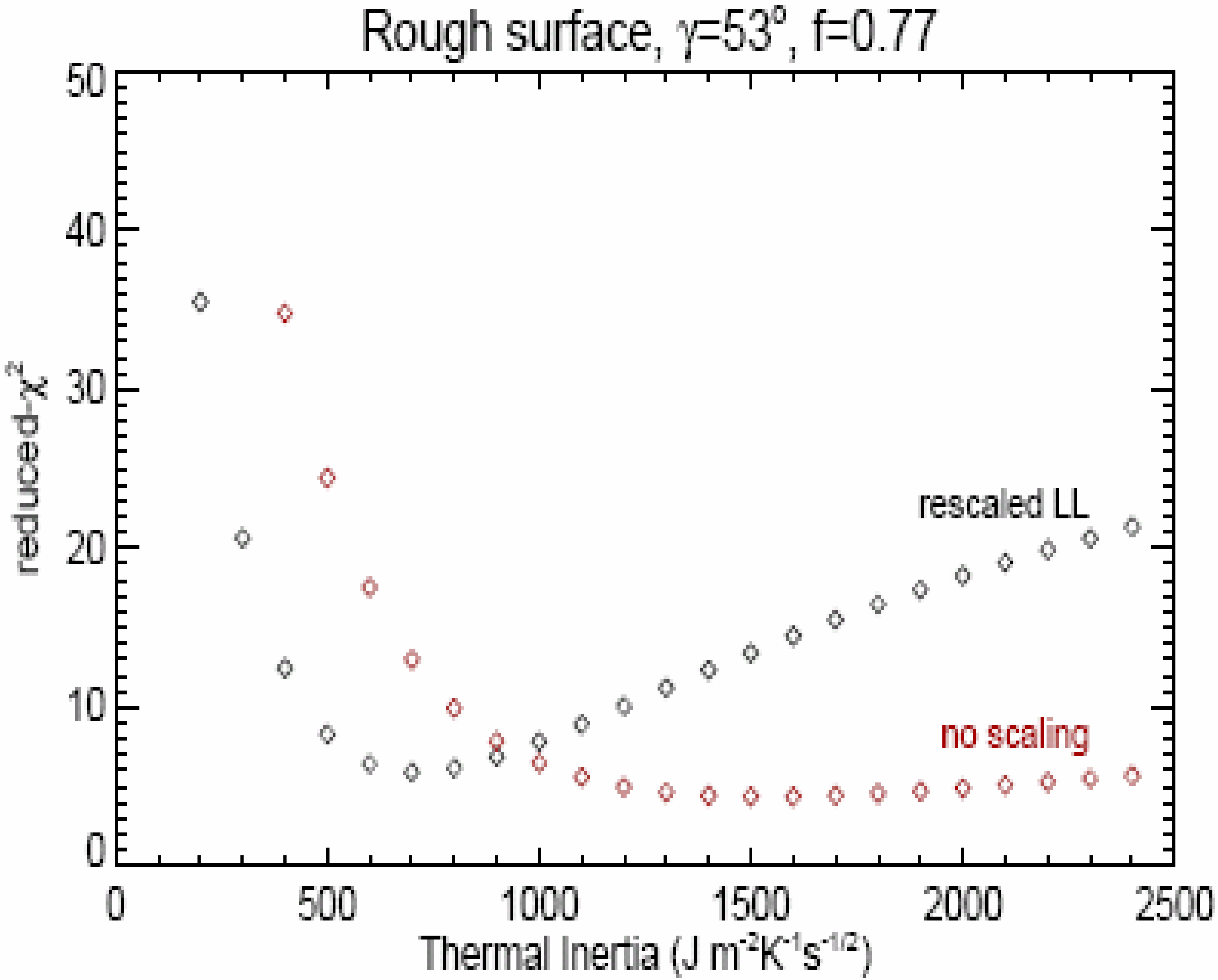
II. Observations and initial results

- 5-38 μm spectrum (Infrared Spectrograph on NASA's *Spitzer* Space Telescope on UT May 2.084, 2008)
- Spectrum has four segments
  - 5.2–8.5 μm (SL2)
  - 7.4–14.2 μm (SL1)
  - 14.0–21.5 μm (LL2)
  - 19.5–38.0 μm (LL1)
- Systematic discrepancy of 10% between the fluxes of overlapping wavelengths in the SL and LL orders → **temperature uncertainty**

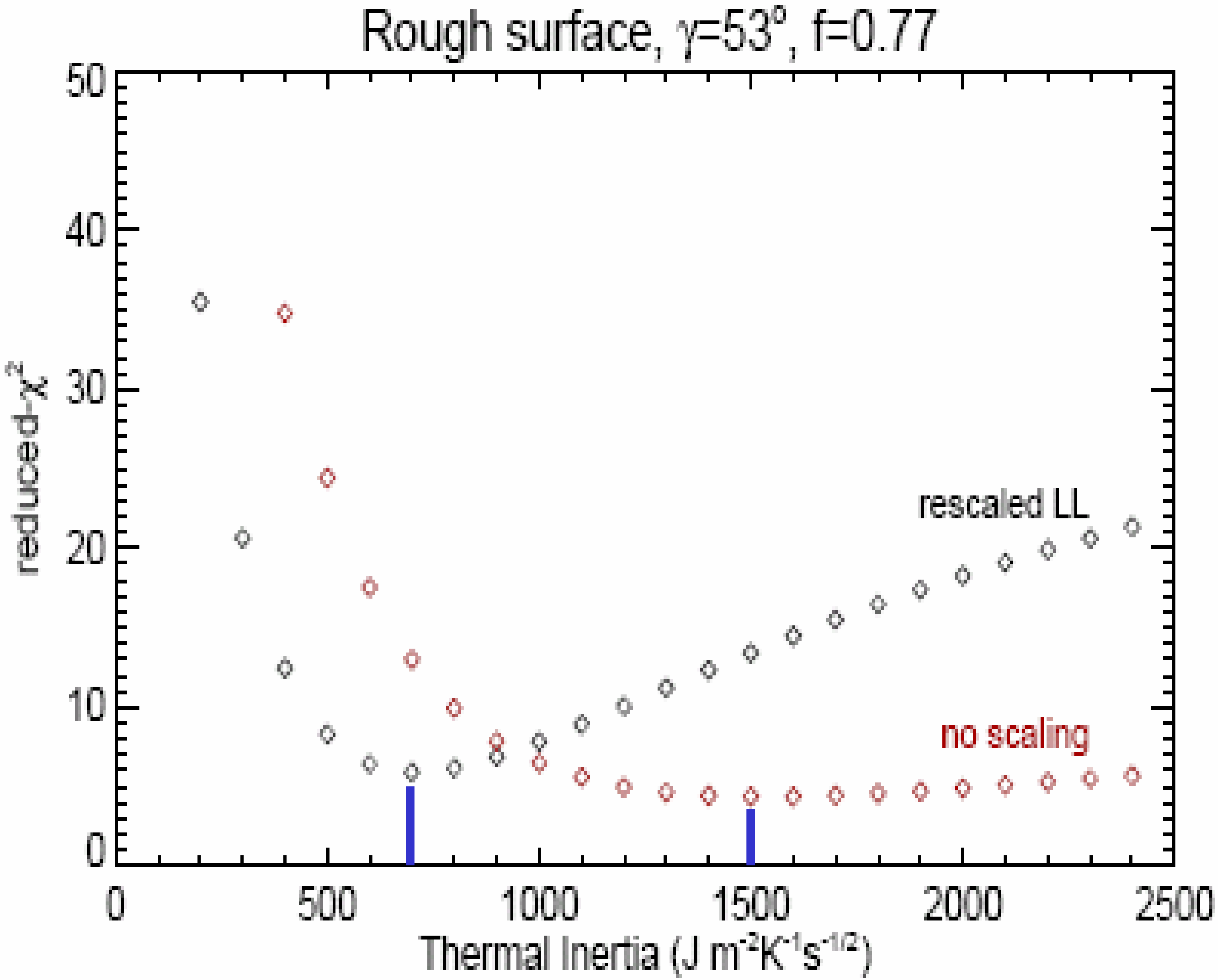

Flux density (mJy)
Wavelength (µm)
Spitzer data - scaled
Rough surface TPM (Γ=700)
0
10
20
30
40
50
60
10
15
20
25
30
35


60
50
40
30
20
10
0
Flux density (mJy)
10
15
20
25
30
35
Wavelength (µm)
Spitzer data - scaled
Rough surface TPM (Γ=700)


Main source of temperature uncertainty
Spitzer data - scaled
Rough surface TPM (Γ=700)
Flux density (mJy)
Wavelength (µm)
0
10
20
30
40
50
60
10
15
20
25
30
35



Rough surface, γ=53°, f=0.77
reduced-χ²
Thermal Inertia (J m⁻²K⁻¹s⁻¹/²)
rescaled LL
no scaling
0
10
20
30
40
50
0
500
1000
1500
2000
2500



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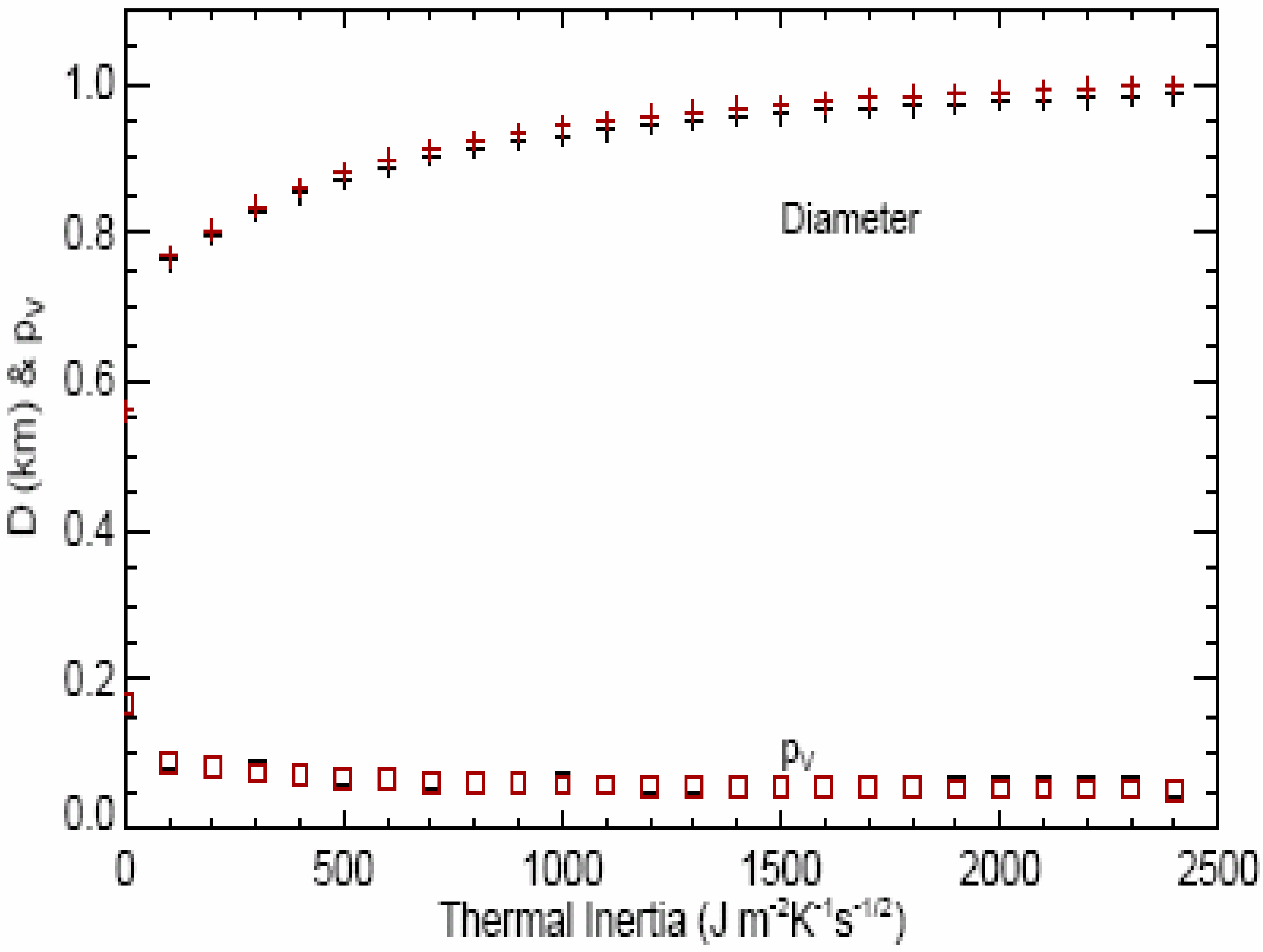
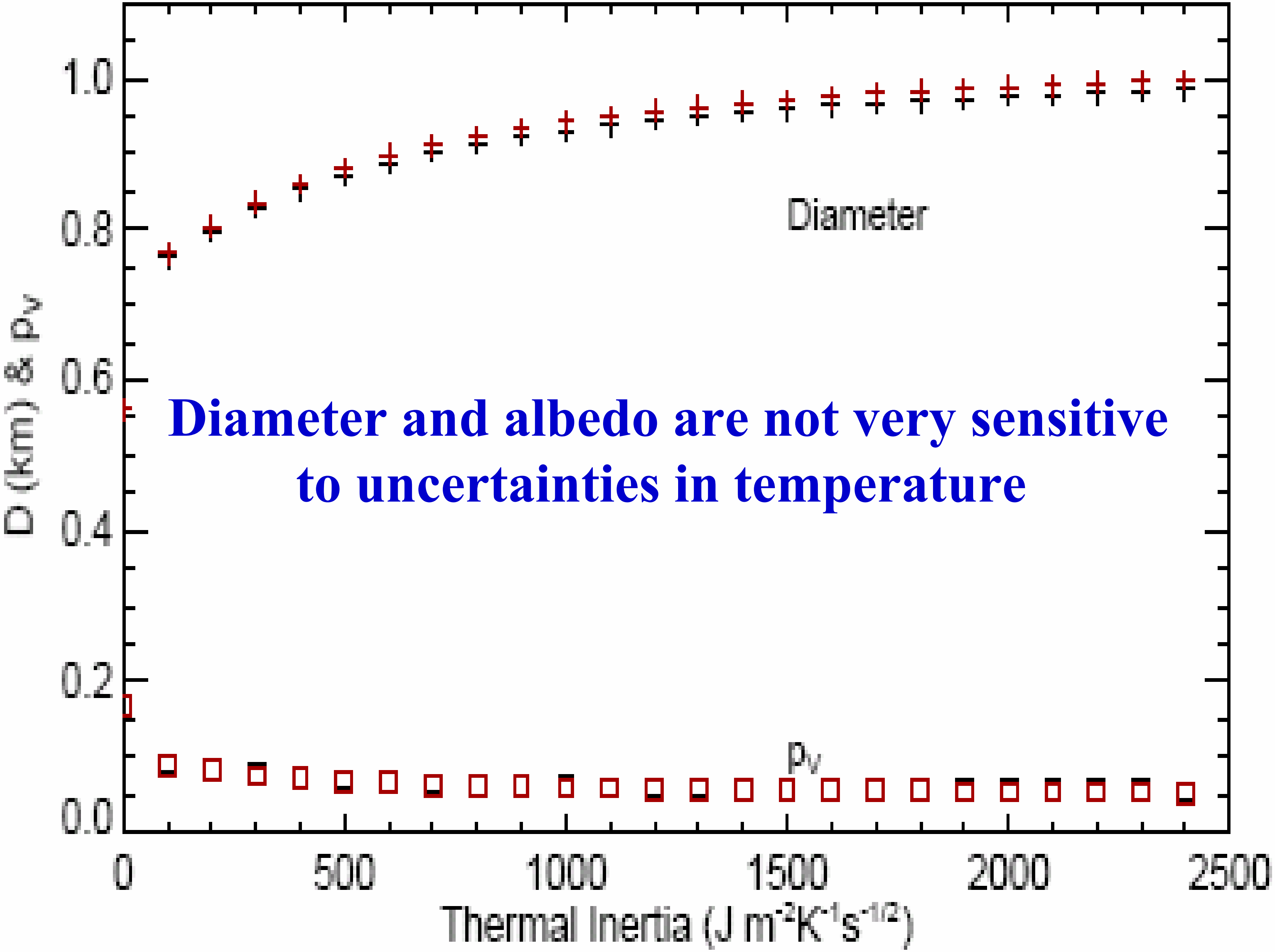
2500



1.0
0.8
0.6
0.4
0.2
0.0
0
500
1000
1500
2000
2500
Diameter
pv
D (km) & pv
Thermal Inertia (J m-2K-1s-1/2)



Diameter and albedo are not very sensitive to uncertainties in temperature
Diameter
p_V
D (km) & p_V
1.0
0.8
0.6
0.4
0.2
0.0
0
500
1000
1500
2000
2500
Thermal Inertia ($J\ m^{-2} K^{-1} s^{-1/2}$)

II. Observations and Initial Results: Diameter and thermal inertia

Model	Scaling	Diameter [†] (km)	η	Γ $(Jm^{-2}s^{-0.5}K^{-1})$	p_V [‡]
NEATM	no scaling	0.97 ± 0.15	1.90 ± 0.17		0.06 ± 0.01
NEATM	scaled orders	0.91 ± 0.14	1.63 ± 0.15		0.07 ± 0.01
TPM	no scaling	0.97 ± 0.15		~1500 (Fig. 2)	0.06 ± 0.01
TPM	scaled orders	0.90 ± 0.14		700 ± 100	0.07 ± 0.01

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III. New constraints on surface properties

- **Thermal inertia (700 $Jm^{-2}s^{-0.5}K^{-1}$) characteristic of pebble-sized surface (mm to cm), similar to asteroid 25143 Itokawa.**
- **We rule out the low thermal inertia case allowed by previous observations**

III. New constraints on surface properties (cont)

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- **Our evidence against a fine and mature regolith is NOT very dependent on spin axis orientation**
- **Even if we had unknowingly observed with pole-on geometry, the thermal model would yield a lower thermal conductivity, and the true value would be even higher, i.e., indicative of an even rockier surface**

III. New constraints on surface properties (cont)

- **Our estimates of diameter and geometric albedo of asteroid 161273 1999 JU_3 are consistent with those of Hasegawa et al. (2008)**
- **However, significant differences with color temperatures of Hasegawa et al. (2008), could be explained by a spin-pole orientation different from that in Abe et al. (2008)**

III. New constraints on surface properties (cont)

- **Asteroid 161273 1999JU$_3$ fits well the trend of increasing thermal inertia with decreasing asteroid diameter (Delbó et al. 2007)**
- **i.e., most or all small NEAs will not have a fine-grained regolith**

Conclusions:

- **Thermal inertia (700 $Jm^{-2}s^{-0.5}K^{-1}$) characteristic of pebble-sized surface (mm to cm), similar to asteroid 25143 Itokawa**
- **Our observations rule out the low thermal inertia case allowed by previous observations**
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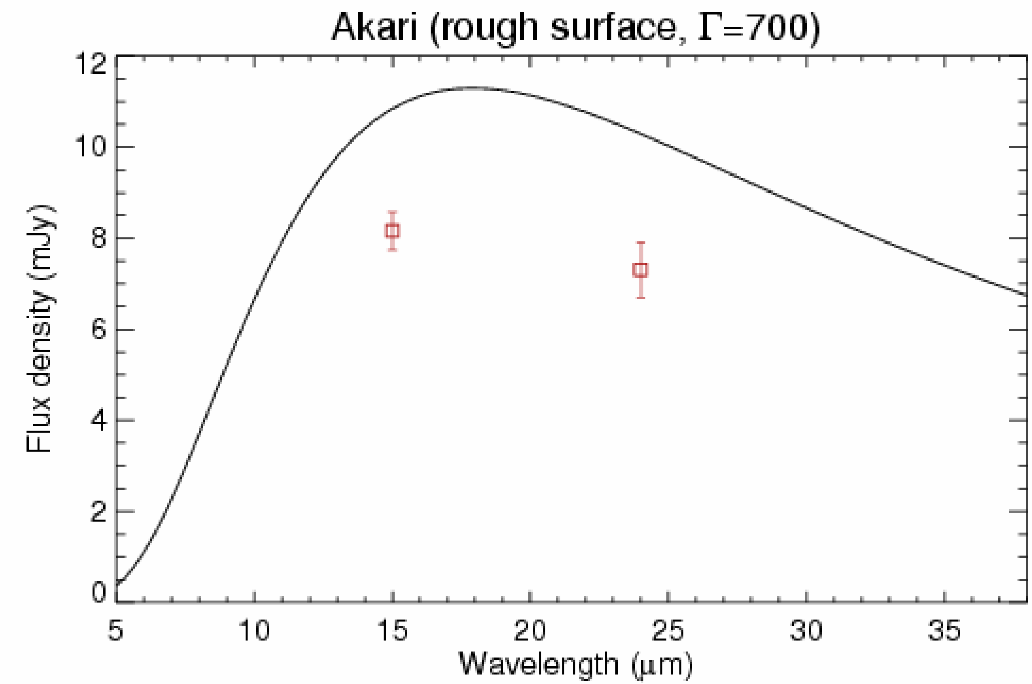
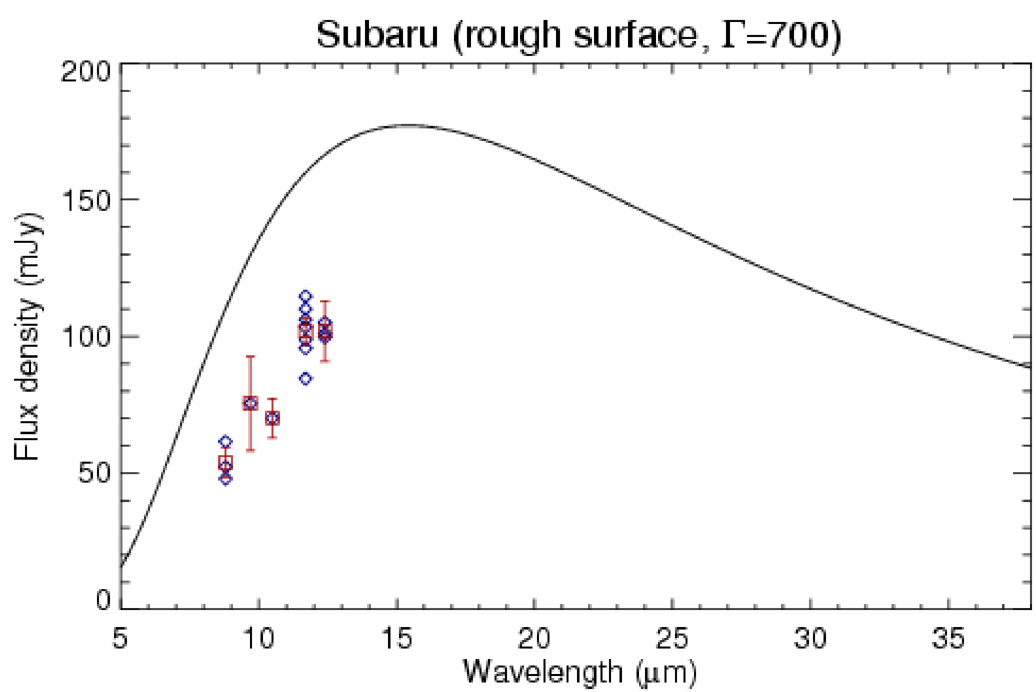
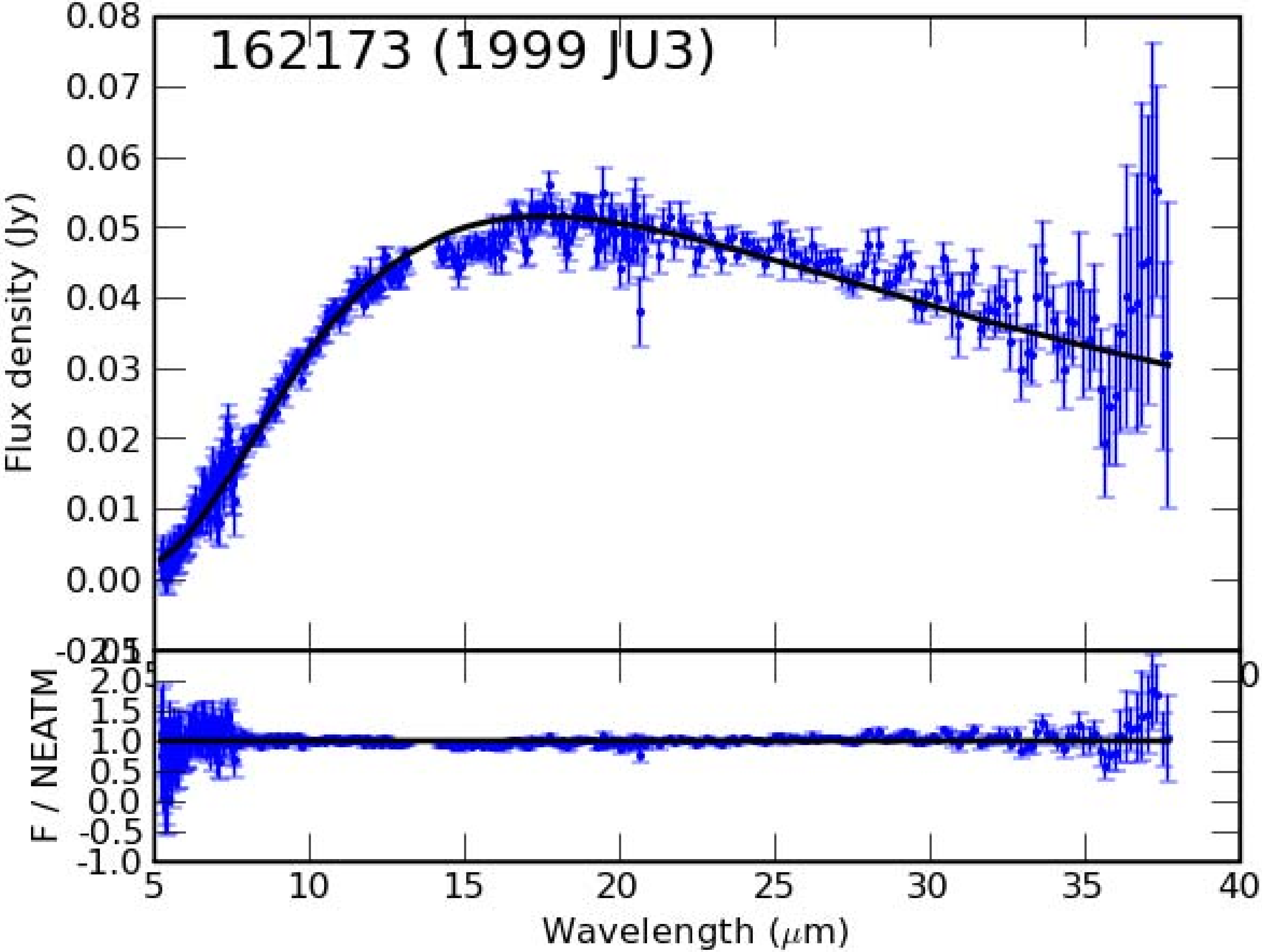
- **Significant differences with color temperatures of Hasegawa et al. 2008, could be explained by a spin-pole orientation different from that in Abe et al. (2008)**

Significant color temperature differences between Spitzer spectrum and Akari and Subaru photometry (Hasegawa et al. 2008)

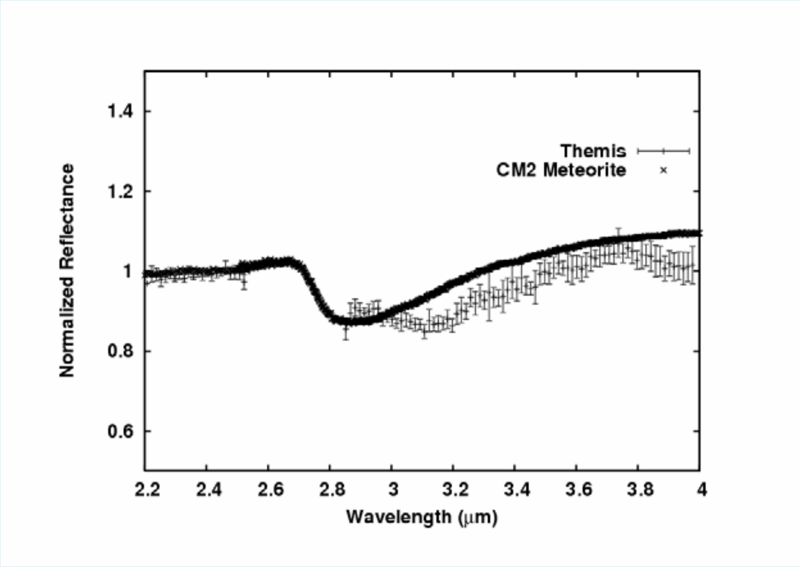


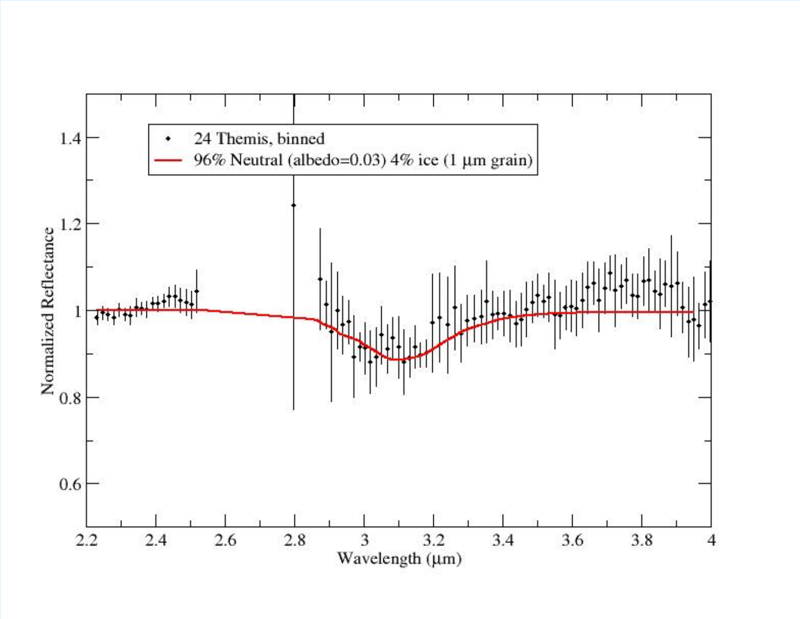




162173 (1999 JU3)
Flux density (Jy)
F / NEATM
Wavelength (μm)
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
5
10
15
20
25
30
35
40

2-4 Micron Spectra of 24 Themis (Rivkin and Emery 2008 and Campins et al. 2009)





Absorption due to **water ice**, not due to hydrated silicates