Spitzer Observations of Spacecraft Target 162173 (1999 JU_3)

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Elisabetta Dotto[5]

1. University of Central Florida, Orlando, USA
2. Instituto de Astrofísica de Canarias, Spain
3. Observatoire de la Cote d'Azur, France
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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

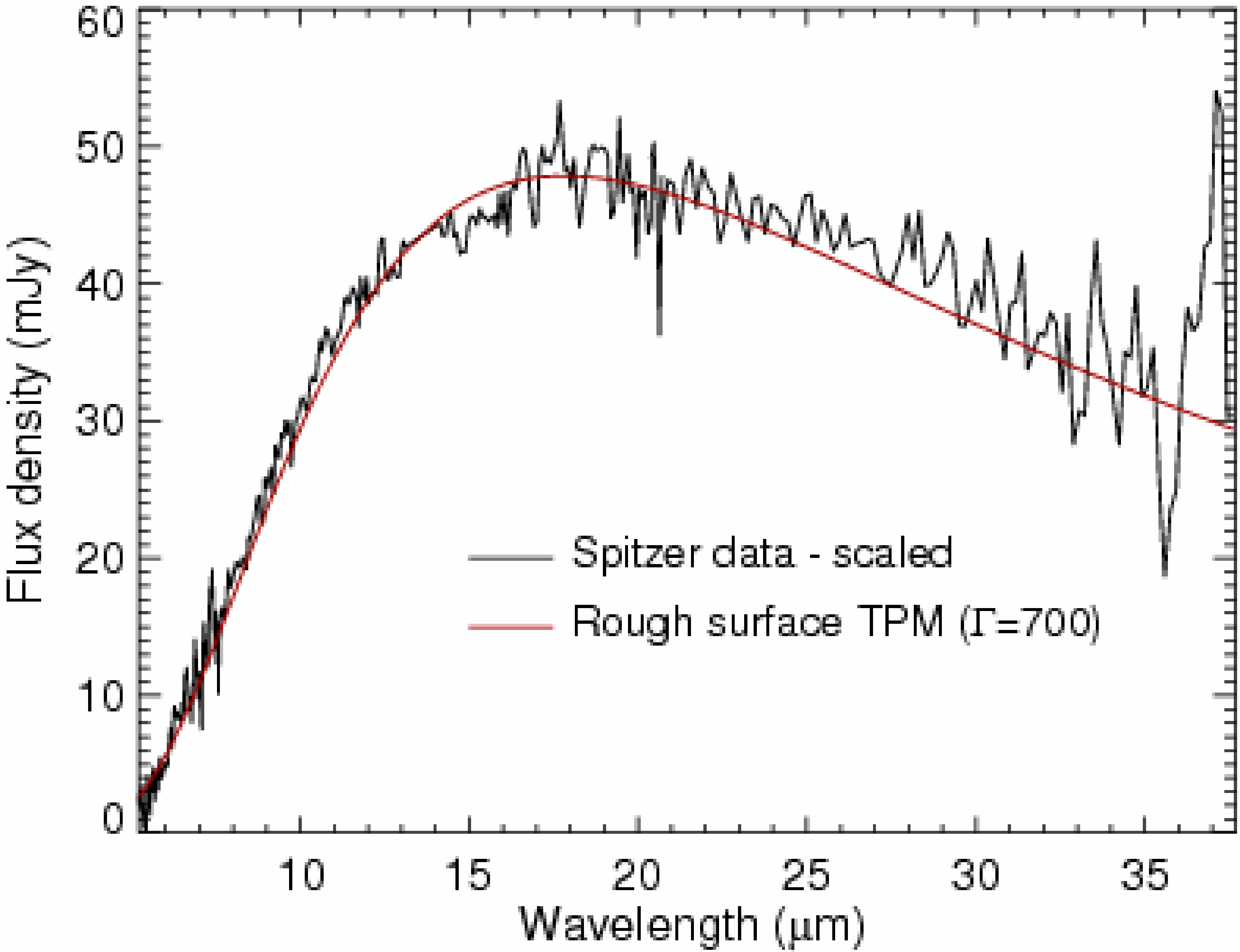
- Mid-infrared (5-38 μm) flux from asteroids is dominated by thermal emission
- Observed Spitzer spectra diagnostic of:
  - Size
  - Composition
  - **Temperature distribution**

I. Introduction

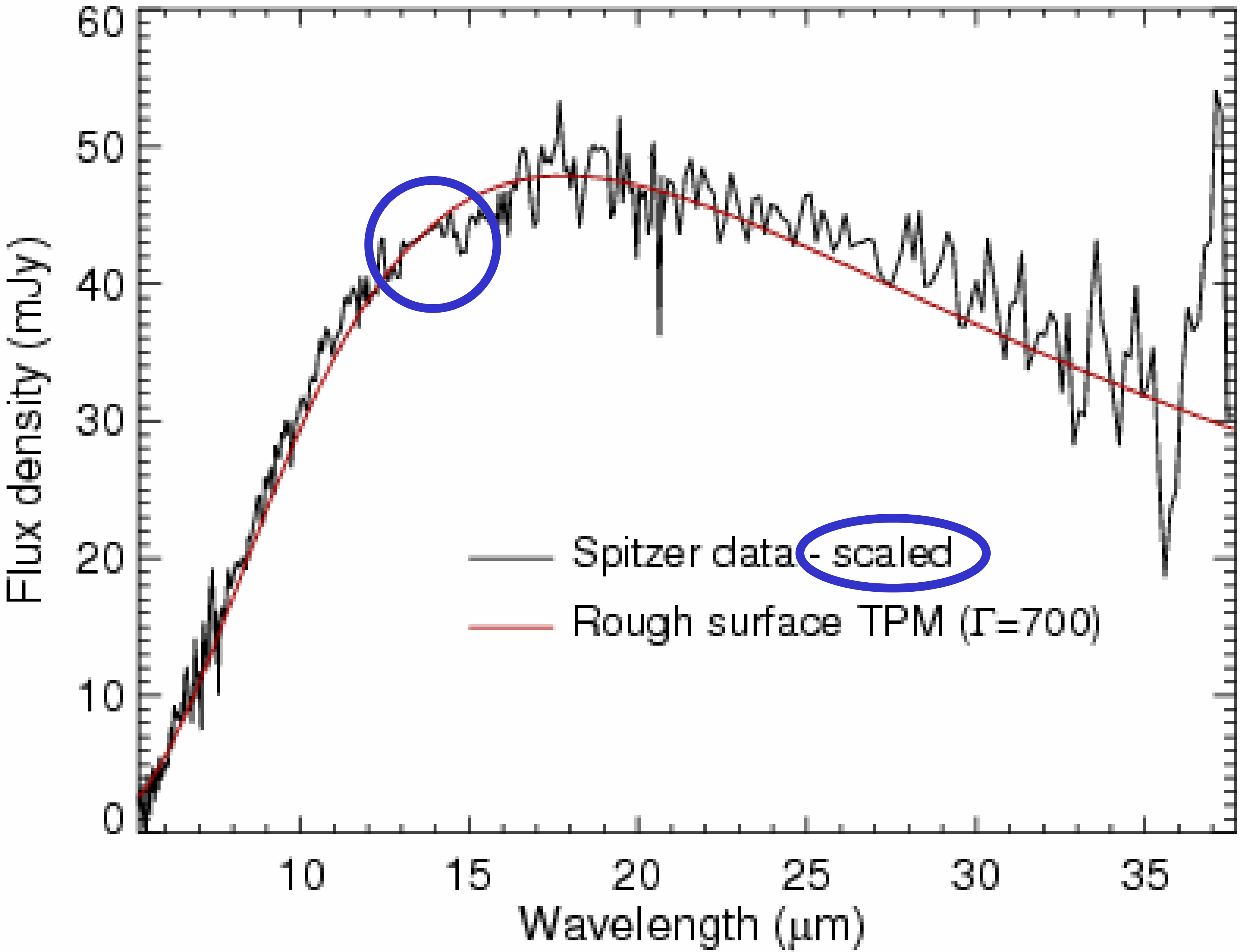
- Mid-infrared (5-38 μm) flux from asteroids is dominated by thermal emission
- Observed Spitzer spectra diagnostic of:
  - Size
  - Composition
  - **Temperature distribution**
- This last term depends on:
  - albedo
  - **thermal inertia**
  - surface roughness
  - rotation rate and **spin-pole orientation**

II. Observations and initial results

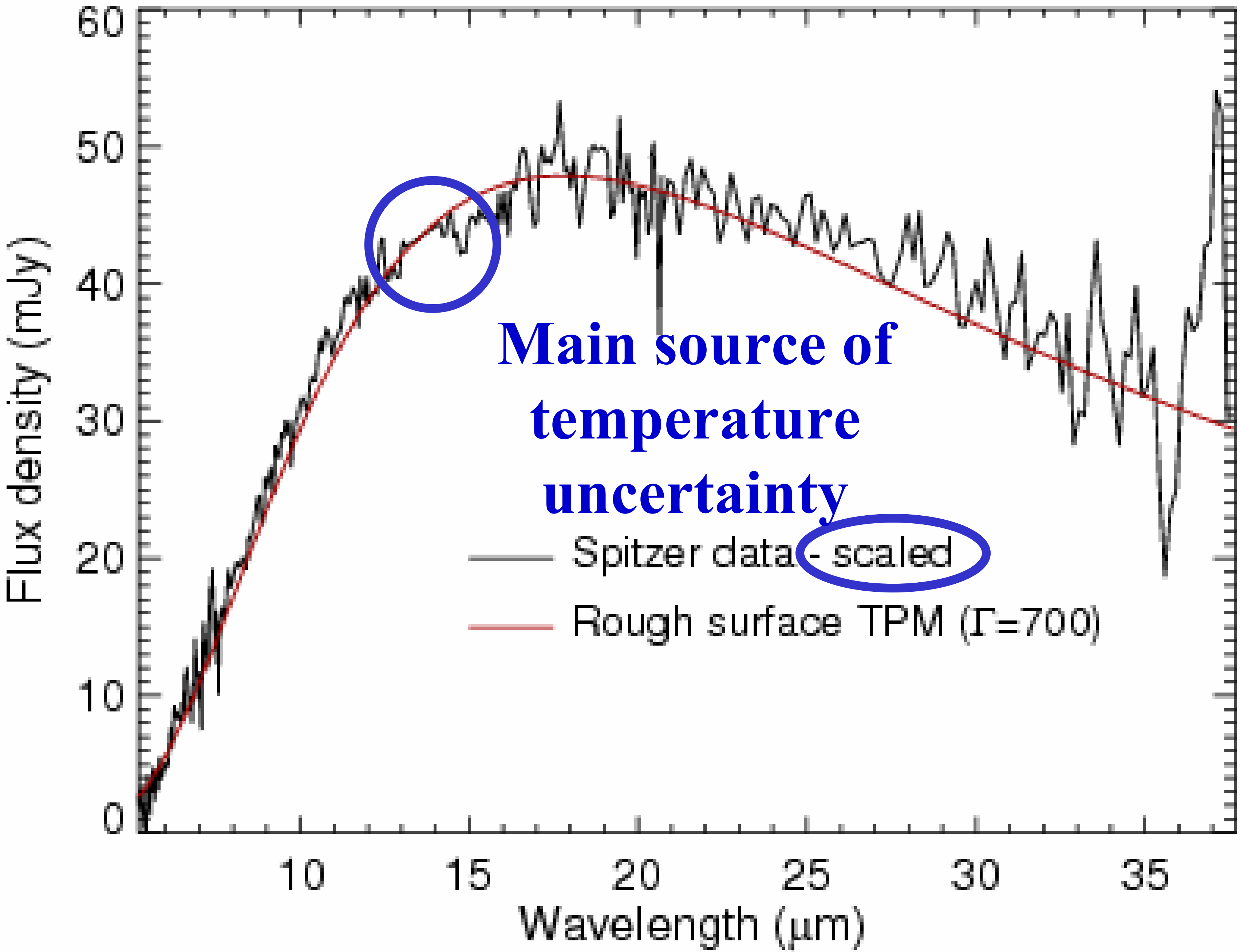
- 5-38 μm spectrum (Infrared Spectrograph on NASA's *Spitzer* Space Telescope on UT May 2.084, 2008)
- Spectrum has four segments
  - 5.2–8.5 μm (SL2)
  - 7.4–14.2 μm (SL1)
  - 14.0–21.5 μm (LL2)
  - 19.5–38.0 μm (LL1)
- Systematic discrepancy of 10% between the fluxes of overlapping wavelengths in the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



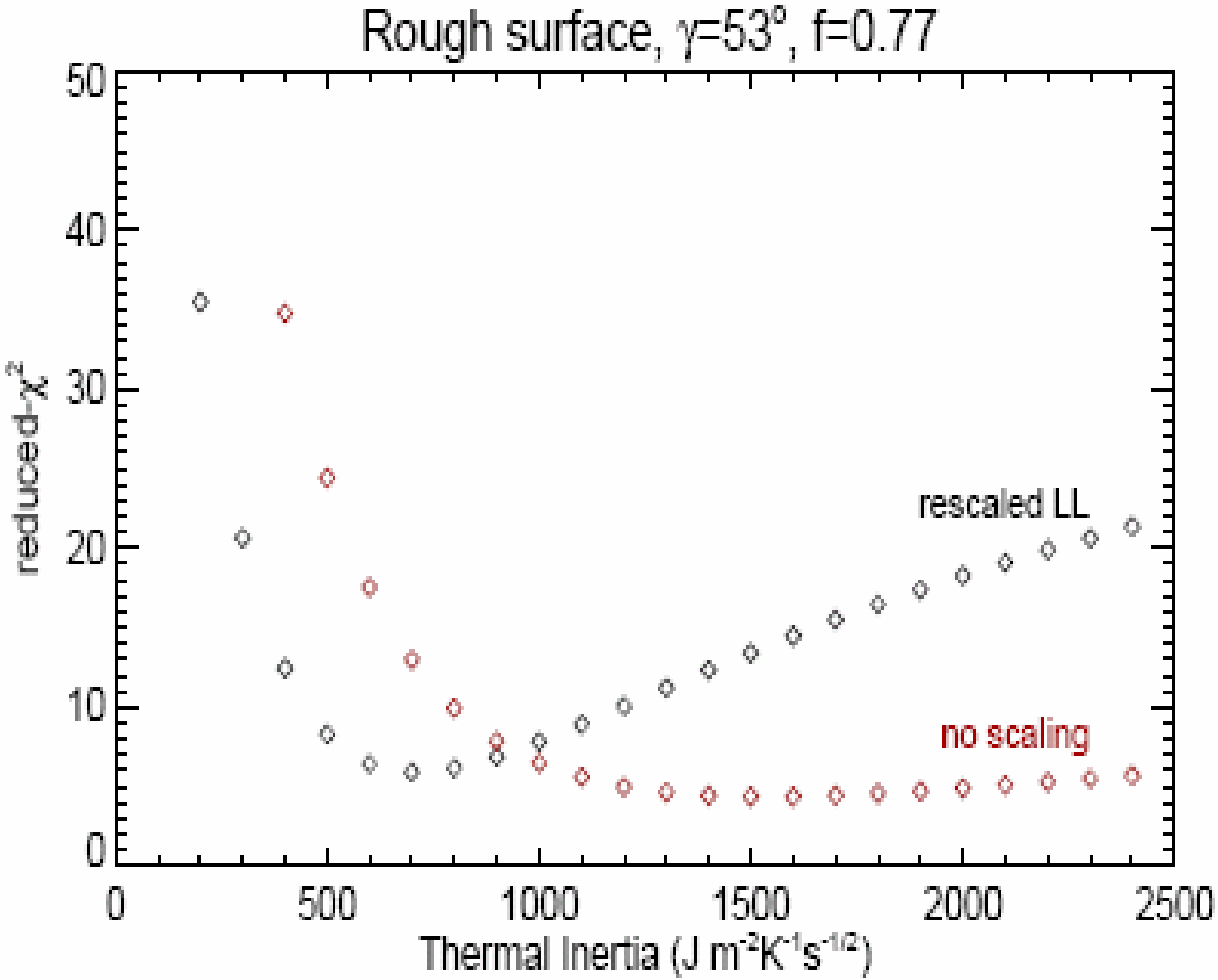
Flux density (mJy)
0
10
20
30
40
50
60
10
15
20
25
30
35
Wavelength (µm)
Spitzer data - scaled
Rough surface TPM (Γ=700)



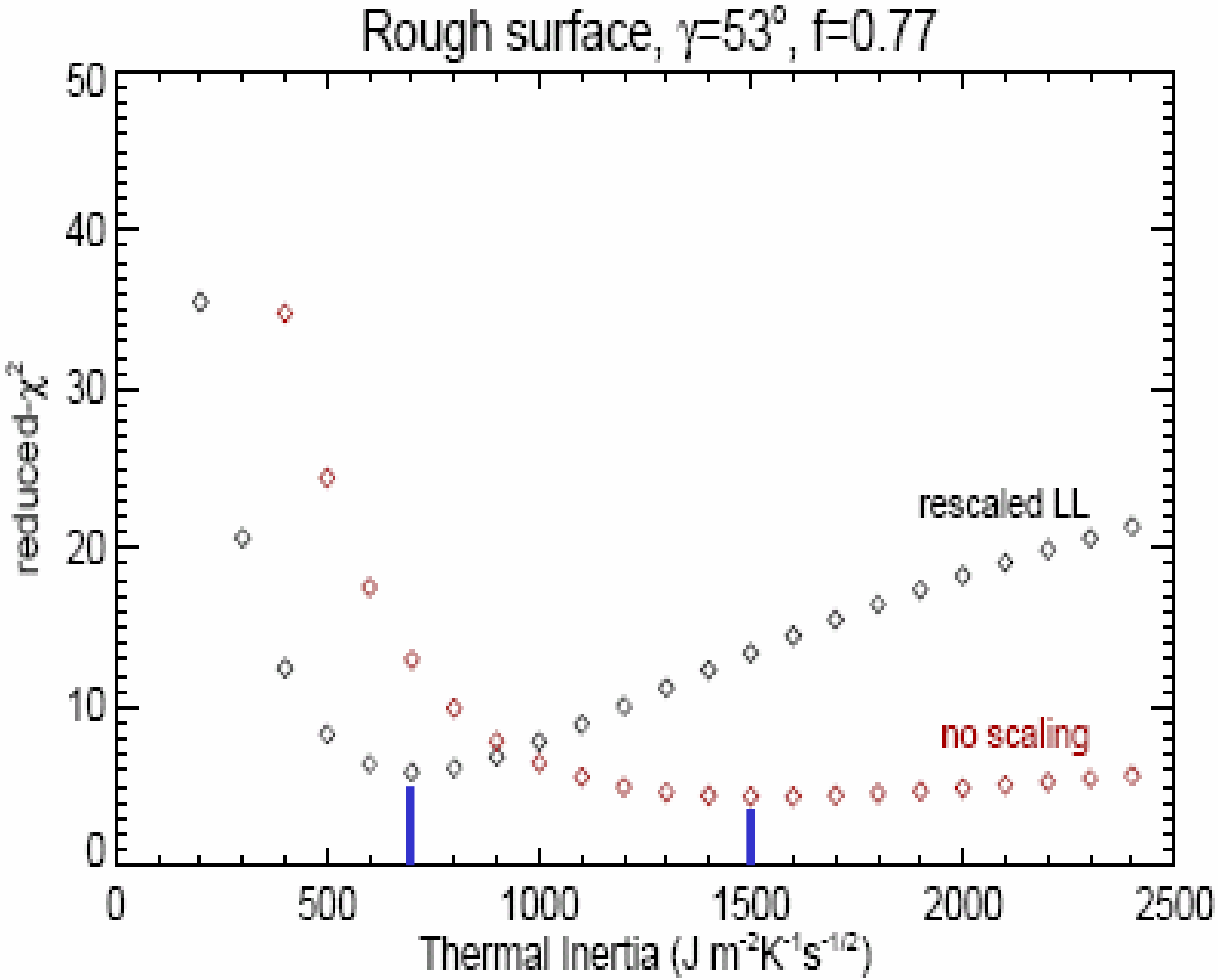
Flux density (mJy)
Wavelength (μm)
Spitzer data - scaled
Rough surface TPM (Γ=700)



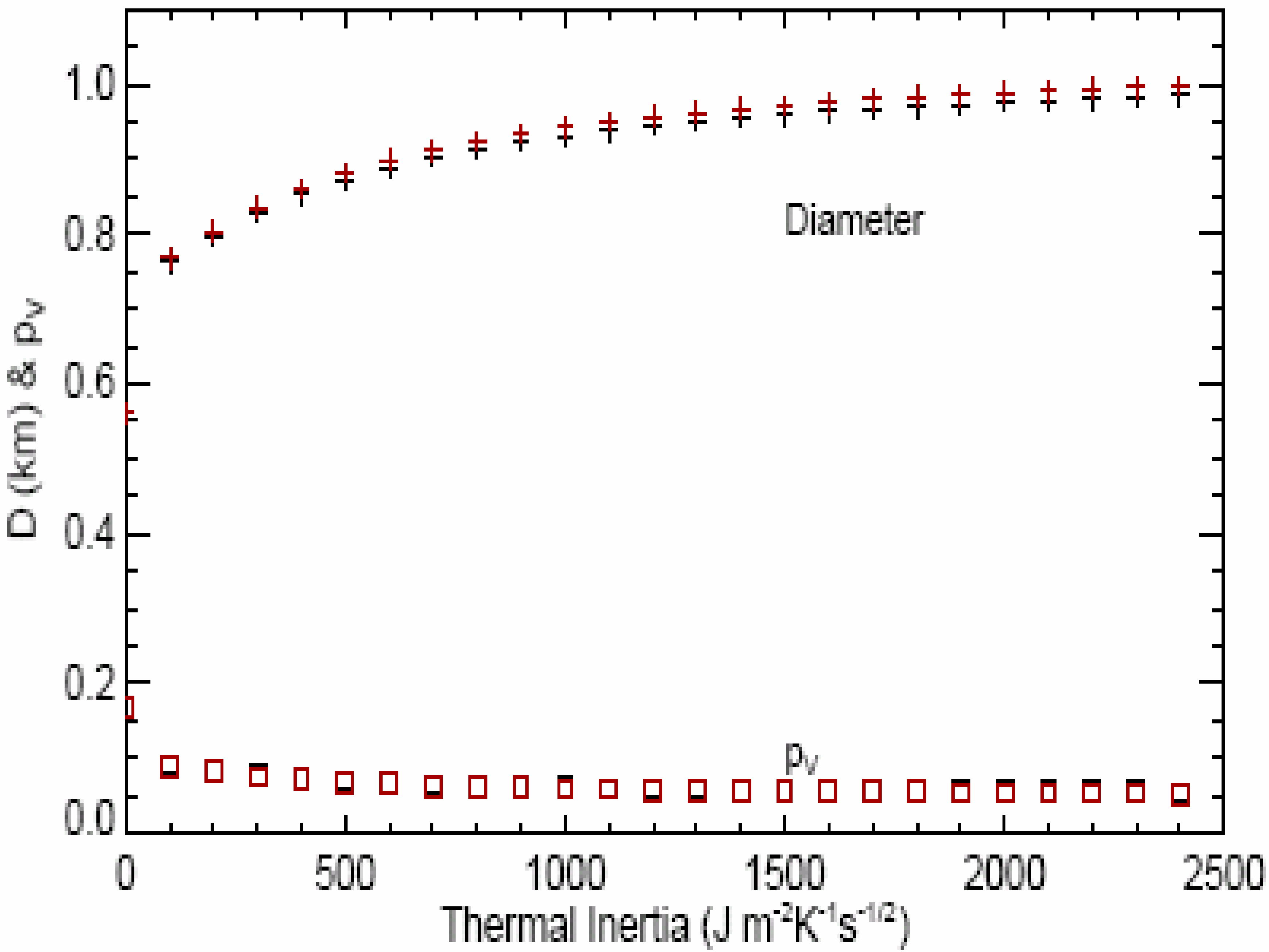
Main source of temperature uncertainty
Spitzer data - scaled
Rough surface TPM (Γ=700)
Flux density (mJy)
Wavelength (μm)
0
10
20
30
40
50
60
10
15
20
25
30
35



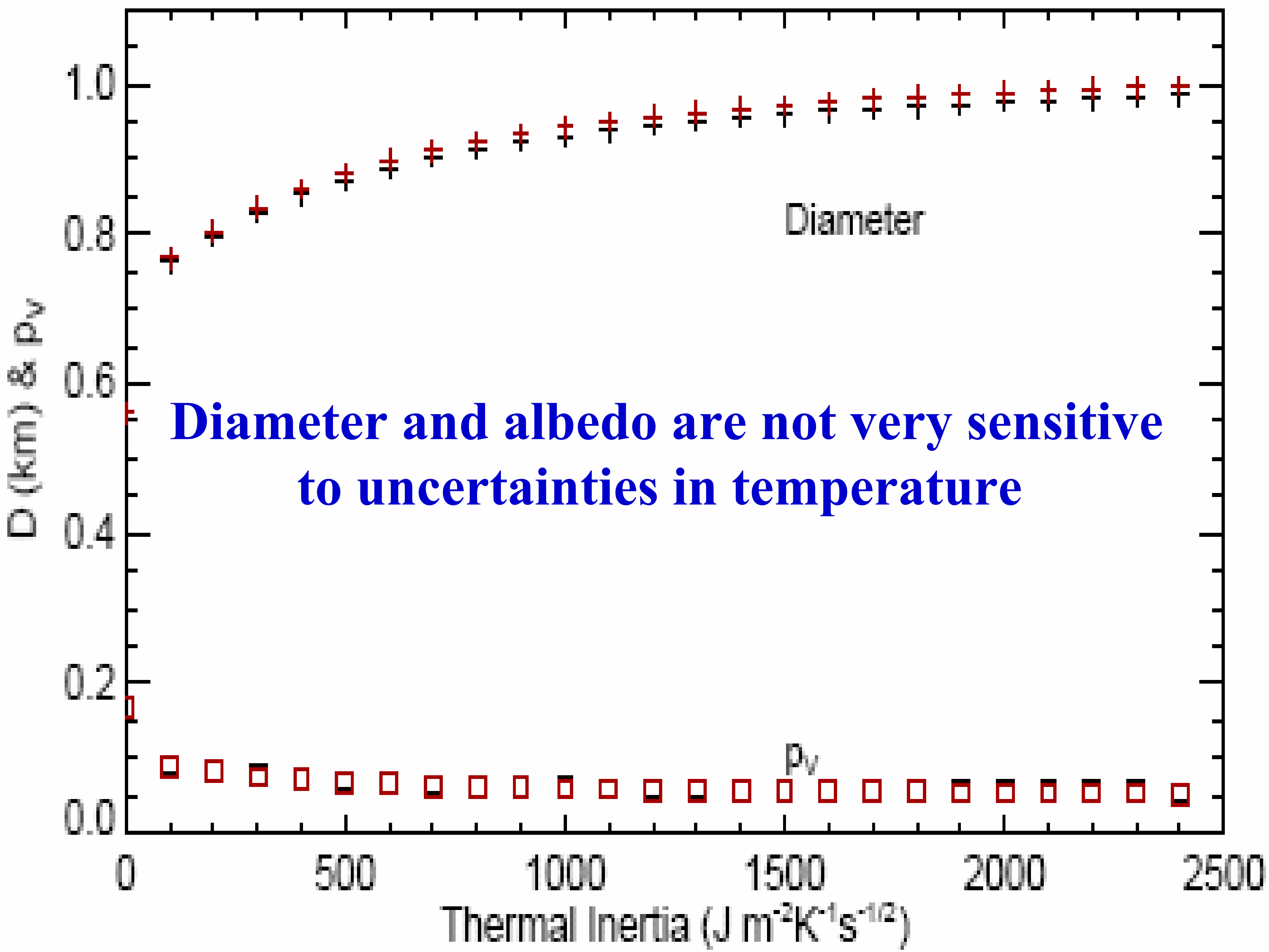
Rough surface, γ=53°, f=0.77
reduced-χ²
Thermal Inertia (J m⁻²K⁻¹s⁻¹/²)
rescaled LL
no scaling
0
10
20
30
40
50
0
500
1000
1500
2000
2500



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



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


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$^{-1/2}$)
Diameter
p_V
Diameter and albedo are not very sensitive to uncertainties in temperature

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:

- <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**
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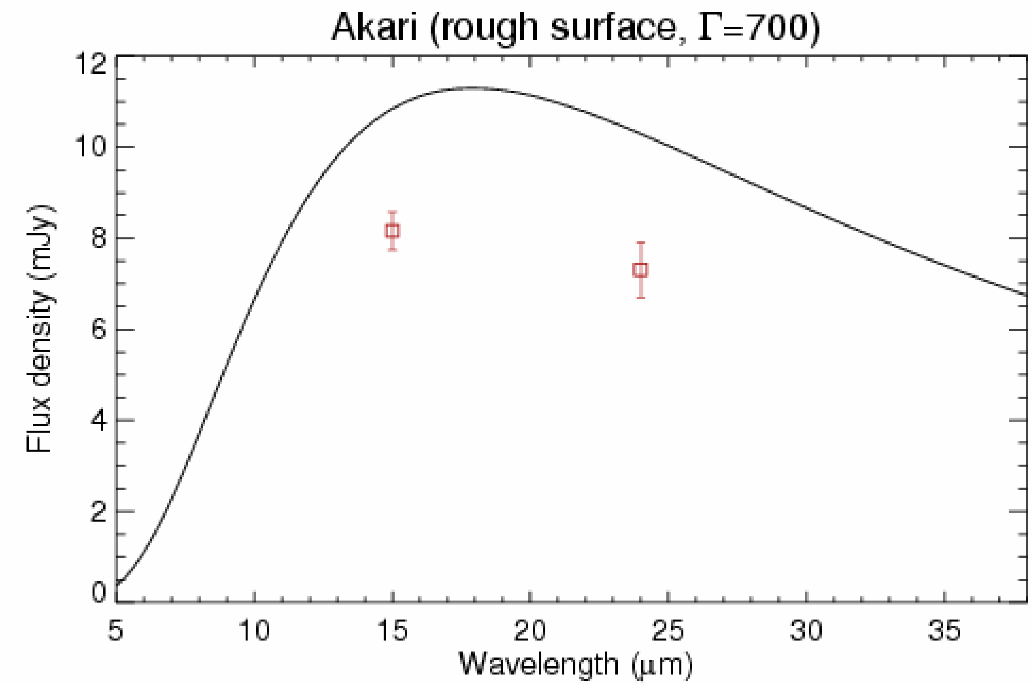
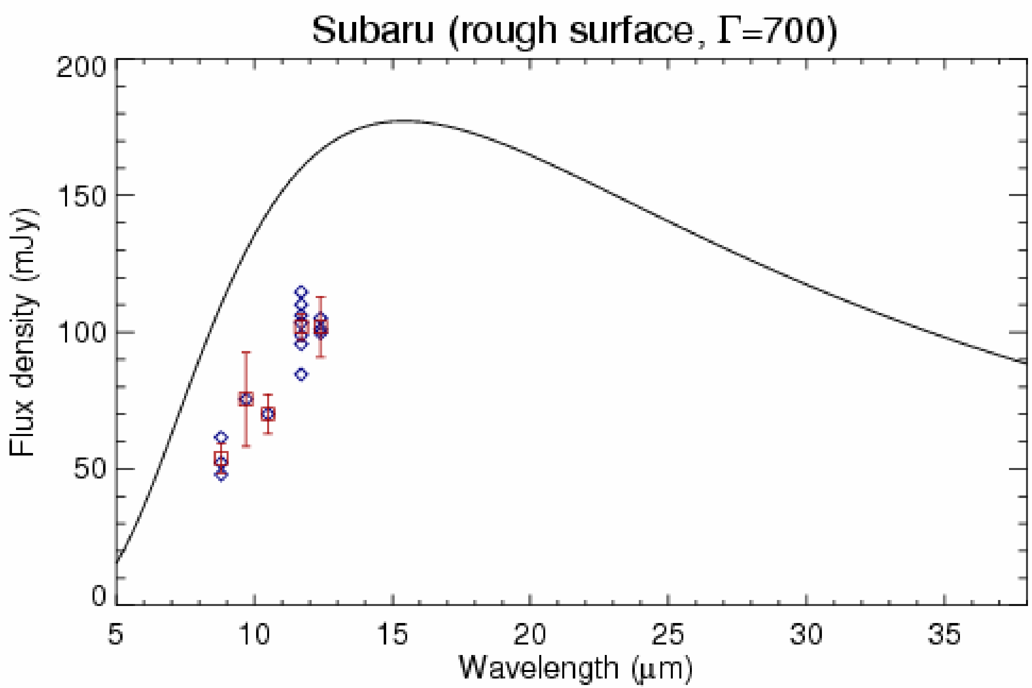
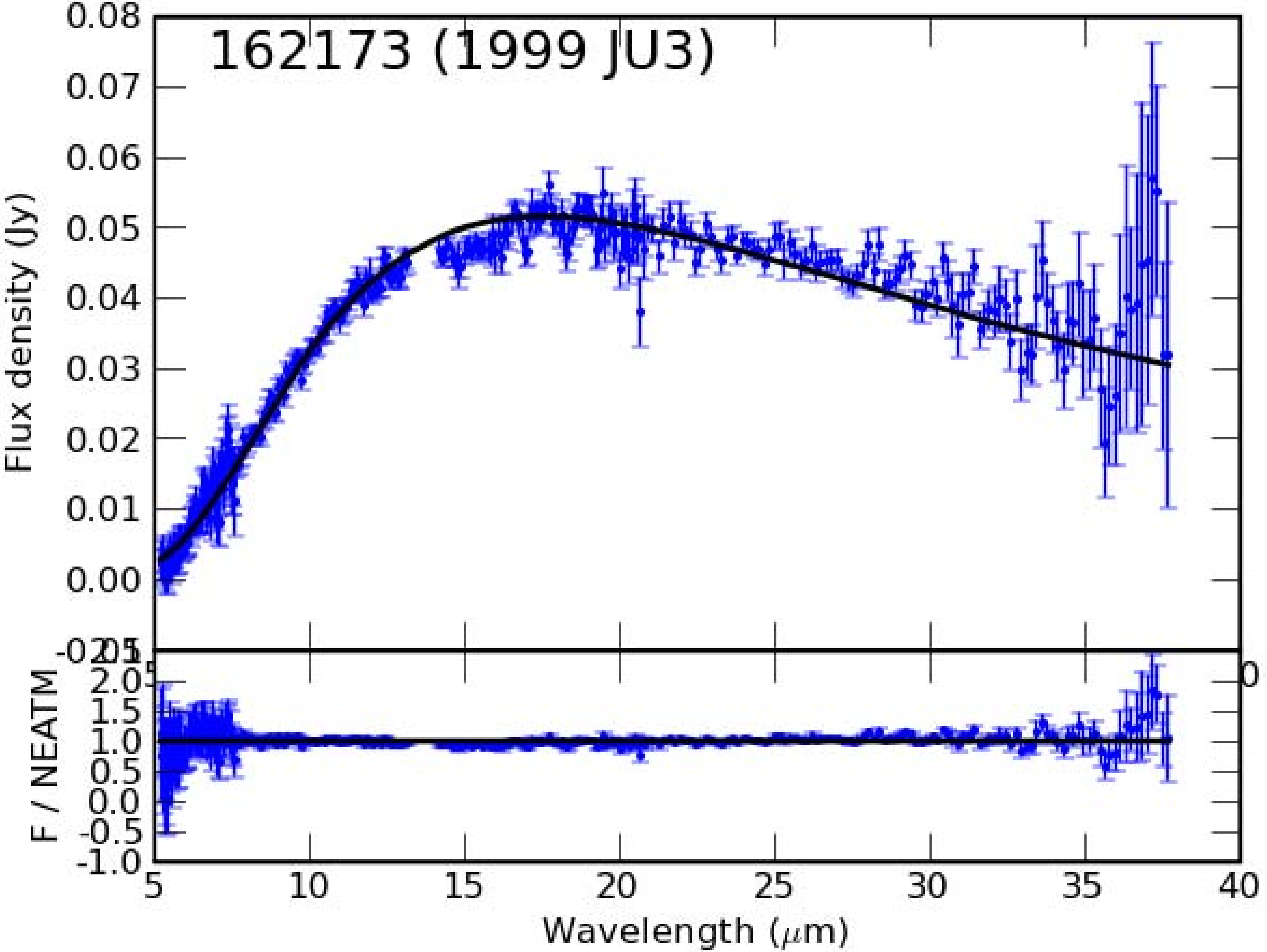
- **Significant differences with color temperatures of Hasegawa et al. 2008, could be explained by a spin-pole orientation different from that in Abe et al. (2008)**

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

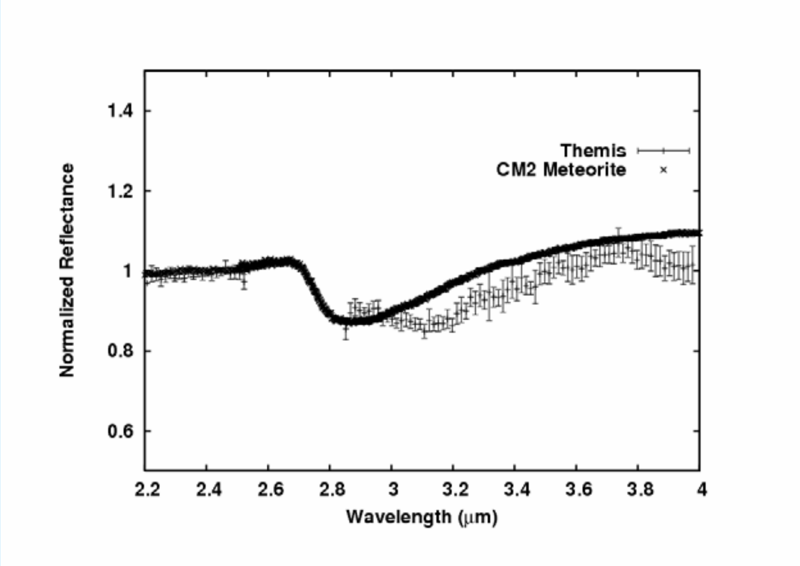


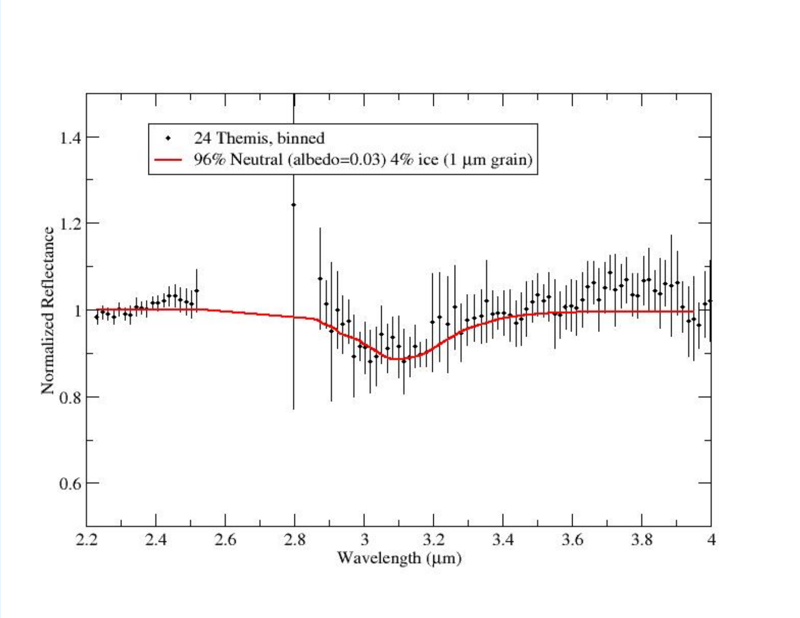




162173 (1999 JU3)
Flux density (Jy)
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
F / NEATM
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
5
10
15
20
25
30
35
40
Wavelength (μm)

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