Spitzer Asteroid Observations and Lightcurves

Herschel Calibration Workshop #2

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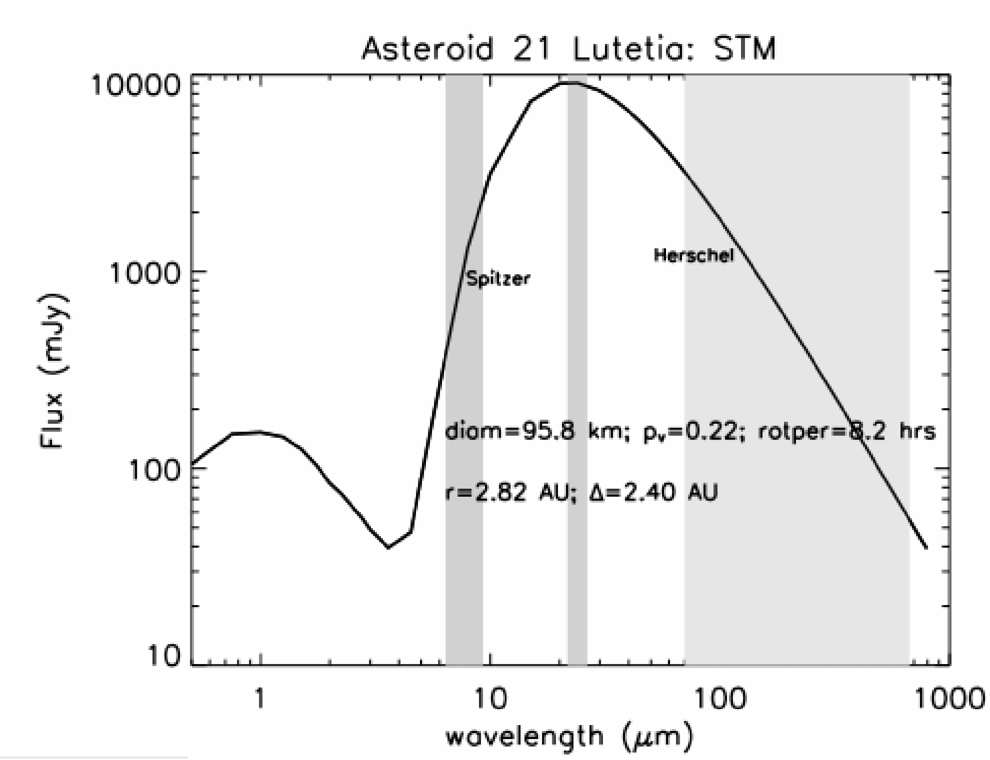
Outline

- Scientific context
- Program overview
- Thermal light curves v
  optical
- Implications for
  Herschel calibration



Background Information

- Why are thermal observations important?
  - *SCIENCE: Diameters and albedos determined from optical/IR observations; surface props*
  - *CALIBRATION: Non-stellar SED's, useful temperatures (bright enough in far-IR/submm)*
- Models of varying complexity used
- Standard Thermal Model (STM)
  - *Spherical asteroid with T dropping off radially away from subsolar point; concentric circle isotherms*
  - *Useful for general determination of SED, preliminary size/albedo determination*
  - *Used for Spitzer 160um calibration source selection (Stansberry, earlier today)*
- Thermophysical models (TPM) parametrize shape, surface properties
- Lightcurves - SCIENCE: Do rotational variations matter? What do they tell us about these objects?
- Lightcurves - CALIBRATION: Although SEDs appropriate for far-IR/submm, are asteroids too variable?

Asteroid Lightcurves: Program Overview

- Spitzer IRAC GTO program, cycle 3 (Feb 2006)
- 8 um lightcurves, 12 points per rotation period
- Look at each object twice -- viewing geometry
- Selected six asteroids whose shape models exist
- These are a challenge for the s/c schedulers! “Dead time” in between exposures.

21 Lutetia - one LC outstanding
42 Isis (now being scheduled)
69 Hesperia - DONE
85 Io - one LC outstanding
93 Minerva - DONE
334 Chicago - DONE

Mueller, et al., 2005

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Asteroid Lightcurves: Program Overview

- All objects are potential Herschel calibrators
  - Roughly spherical

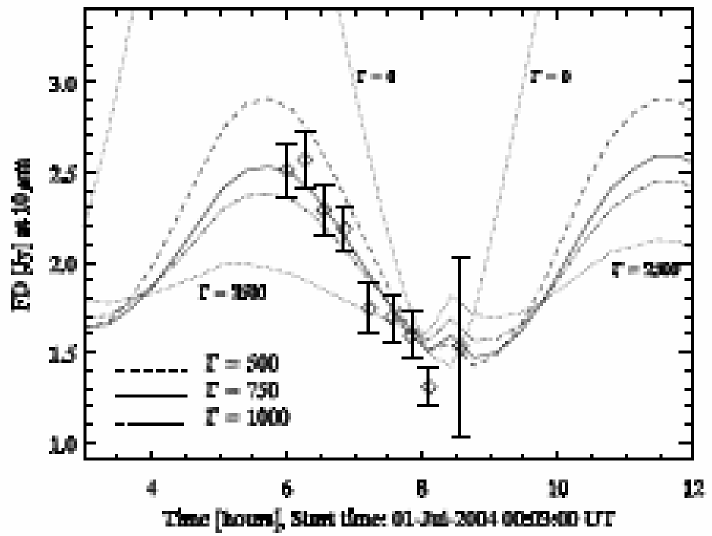


Fig. 5. Predicted thermal lightcurve at 10.0μm for the time period around the July 1st, 2004 observations. The original measurements were "transported" to the 10.0 μm wavelength via our TPM solution. Predictions and measurements are shown with their absolute values, no shifting or scaling in time or flux have been done.

Mueller, et al., 2005

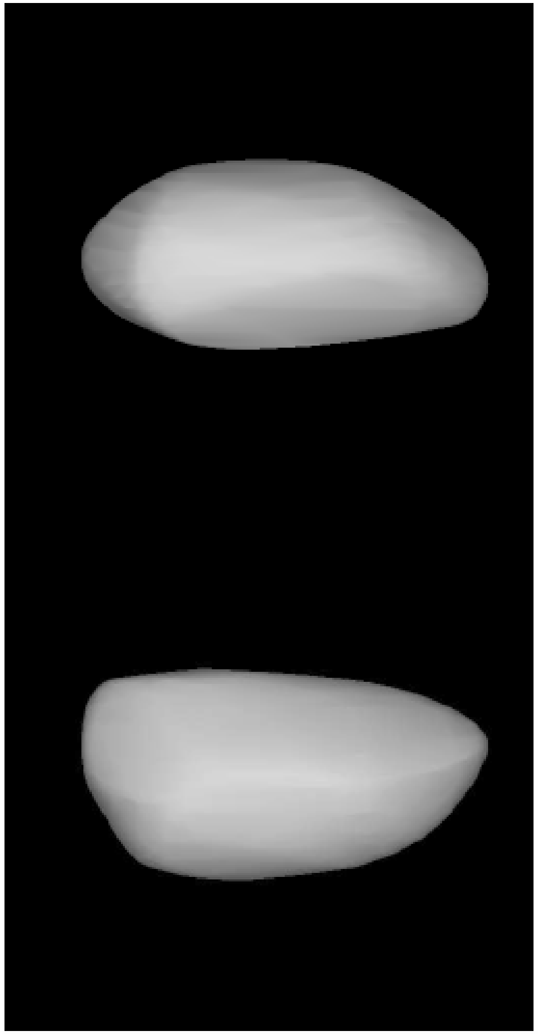
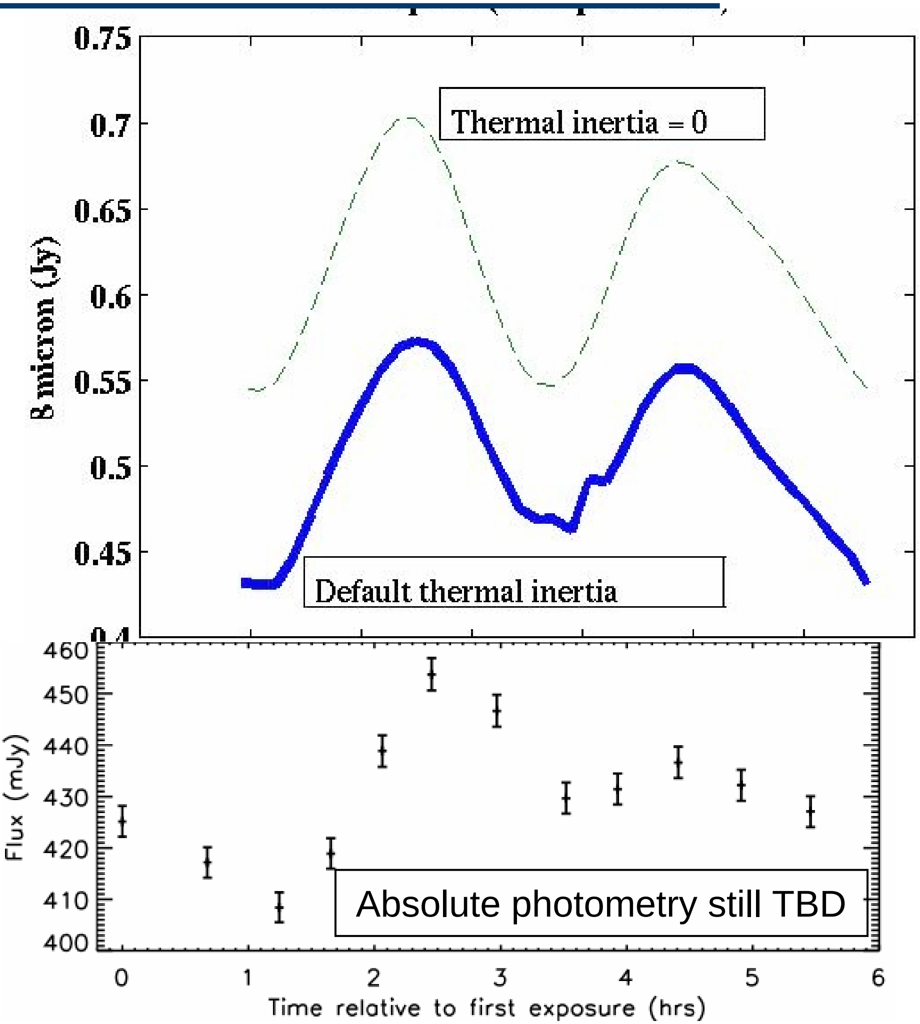


Fig. 2. Equatorial edge-on (top) and pole-on (bottom) images of the shape model.

Asteroid Lightcurves: IR vs. optical, 69 Hesperia

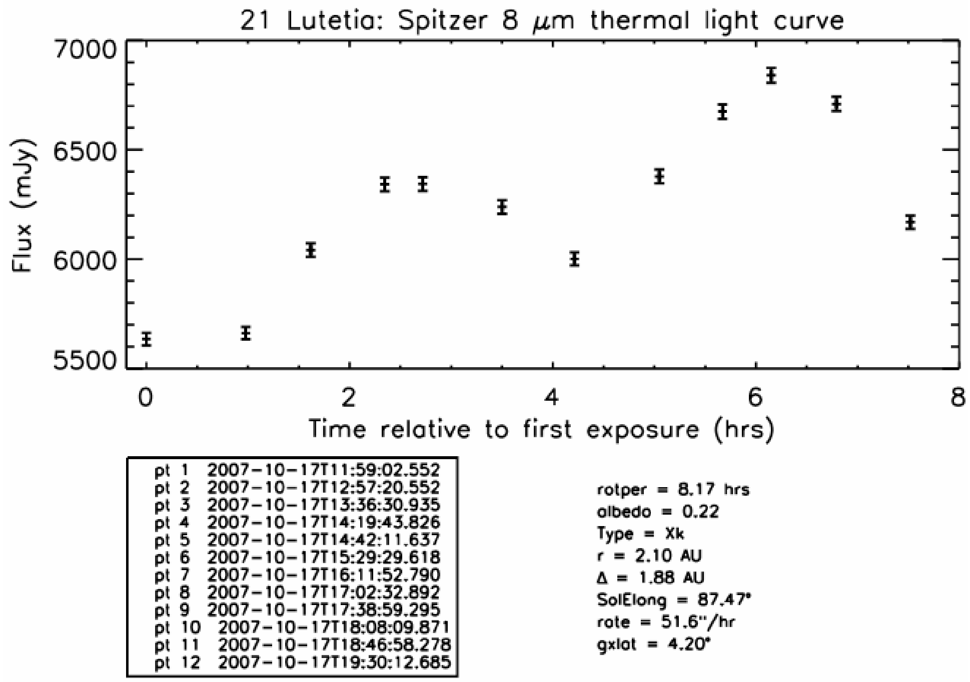
- Lightcurves dominated by shape (cross-sectional area).
  - Top: TPM 8um lightcurve for 69 Hesperia, 2007-06-29, T. Mueller
  - Bottom: Spitzer IRAC 8 um lightcurve for 69 Hesperia, 2007-06-29
- TPM effective in predicting flux
- Peak-to-Peak modeled variation ~ 33%
- Peak-to-Peak observed variation ~ 10%
- Thermal attenuation may be due to incorrect shape or unforseen albedo variations
- Phasing may be due to thermal inertia



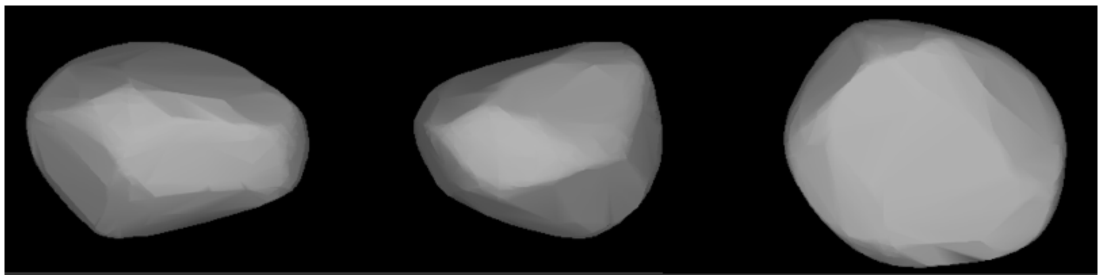
rotper = 5.66 hrs
albedo = 0.14
Type = X
r = 3.47 AU
Δ = 2.96 AU
SolElong = 112.20°
rate = 6.7"/hr
gxlat = 34.68°

Asteroid Lightcurves: IR vs. optical, 21 Lutetia

- Top : Spitzer IRAC 8 um lightcurve for 21 Lutetia, 2007-10-17
- Bottom: 21 Lutetia shape model, Kaasalainen
  - http://astro.troja.mff.cuni.cz/~projects/asteroids3D/



- TPM ~ 5780 +/- 750 mJy
- Peak-to-Peak modeled var ~ 26%
- Peak-to-Peak observed var ~ 23%
- Feature at t+4 hrs needs further study



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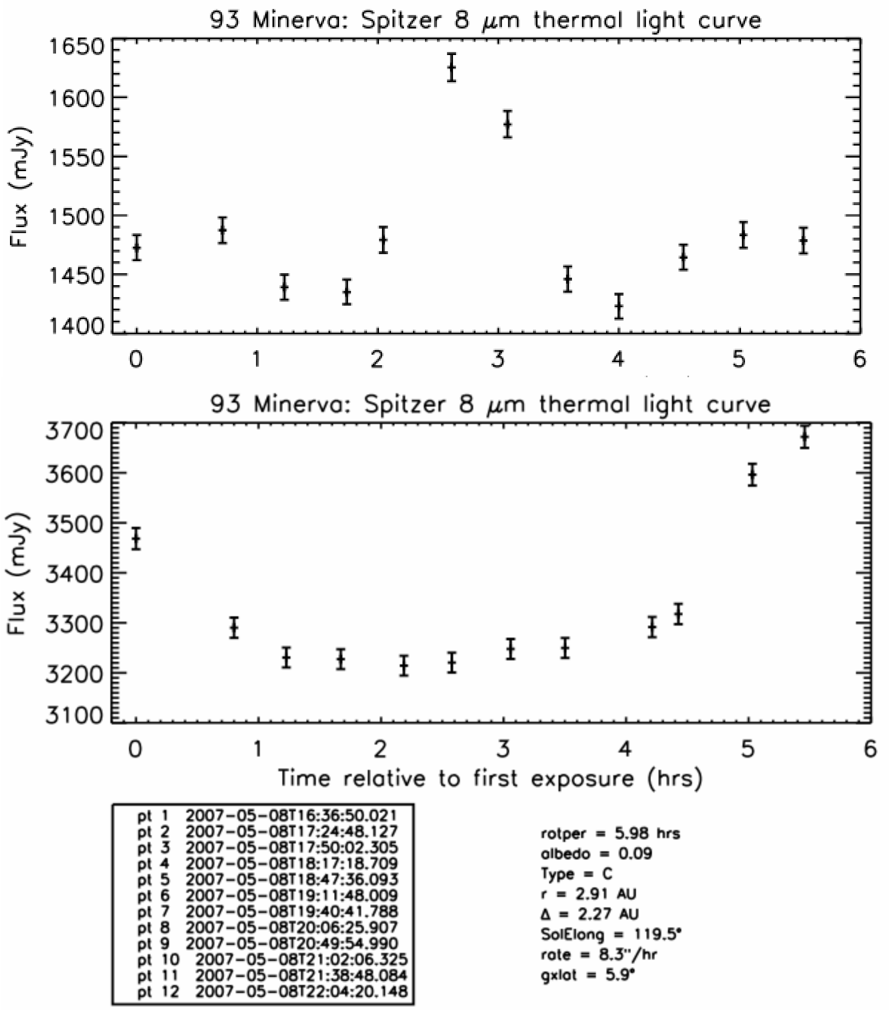
Asteroid Lightcurves:
IR vs. optical, 93 Minerva

- Viewing geometry matters!
  - Top : Spitzer IRAC 8 um lightcurve for 93 Minerva 2006-12-27
  - Bottom : Spitzer IRAC 8 um lightcurve for 93 Minerva 2007-05-08



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Asteroid Lightcurves: 24 um

Spitzer MIPS 24 um lightcurve for Trojan asteroid

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

Asteroid Lightcurves:
Conclusions & Implications for Herschel Calibration

- The thermophysical model is effective for predicting absolute flux levels
- Peak-to-peak amplitudes are less than predicted by TPM
- Need to further consider 8um phot. analysis -- few % difference in absolute
- Possible need to update shape models
  - some shape features may not be real
- Possible need to adjust thermal inertia
  - thermal variability may be due to changes in albedo
- **The bottom line: Even though asteroids rotate and have variable surfaces, their thermal variability may be less than what is seen at optical wavelengths. They are effectively modeled by the TPM and are well-suited for calibration of Herschel**

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