MARCO POLO-R TARGET ASTEROID (175706) 1996 FG3: POSSIBLE EVIDENCE FOR AN ANNUAL THERMAL WAVE. R. P. Binzel[1], D. Polishook[1], F. E. DeMeo[1], J. P. Emery[2], A. S. Rivkin[3] [1]Massachusetts Institute of Technology, Cambridge MA (rpb@mit.edu), [2]Univ. of Tennesee, Knoxville, TN, [3]JHU/APL, Laurel MD

Introduction: Asteroid (175706) 1996 FG3 is a C-type near-Earth asteroid [1] selected as the prime target for the *Marco Polo-R* sample return mission proposed to the European Space Agency. Its low albedo of 0.045 [2] and 0.7 AU perihelion provide opportunity for measurments of its thermal flux.

Observations: Measurements using the SpeX instrument on the NASA Infrared Telescope Facility (IRTF) in prism mode (0.8-2.5 μm) have been made as part of a routine reconnaissance program [3] during apparitions of 1996 FG3 in 2009 and 2011. Significant spectral differences (but still broadly consistent within the C-class) have been noted for FG3 between these two years [4], where the differences include an apparent discordance in the measured thermal flux (2.0-2.5 μm) even when the asteroid is at similar heliocentric distance and solar phase angle.

Observational Results: We illustrate in **Figure 1** the spectral discordance for two sets of IRTF SpeX observations [3] of asteroid 1996 FG3. The dates of observation were 2009-04-27 UT and 2011-12-01 UT, where the differences in heliocentric distance (1.08 versus 1.05 AU) and phase angle (58.4 versus 51.3 degrees, respectively) are minimal. We note that the 2009 measurements (minimal thermal flux) were made pre-perihelion, while the 2011 measurements (substantial thermal flux) were made post-perihelion. Respectively in orbital longitude, the measurements occur at -114 and +110 degrees relative to perihelion.

Interpretation: The known low obliquity pole [5] for asteroid 1996 FG3 (and its low orbital inclination) keep the sub-Earth and sub-solar latitudes relatively equatorial to within about +/- 20 degrees. While N/S hemispherical differences in thermal properties cannot be ruled out as a difference between the 2009 and 2011 measurements, we have additional data at least showing no measureable rotational (longitudinal) thermal variations. In addition we have spectral data showing no measurable variation in or out of satellite eclipse.

We propose as a possible explanation that our measurements are revealing the annual thermal cycle for asteroid 1996 FG3. As the asteroid approaches perihelion, the thermal wave (increasing temperature) penetrates deeper and deeper into the interior of the asteroid. Post-perihelion this thermal wave reverses, emitting maximum thermal flux back into space as the asteroid heads towards aphelion; consistent with the orbital longitude for the 2011 measurements. (Total orbital period is 395 days.) The asteroid surface is at its coolest value (lowest average temperature) as it comes inbound toward its next perihelion; consistent with the orbital longitude for the 2009 measurements. An important factor for the emitted flux for 1996 FG3 being dominated by an annual thermal wave, rather than a diurnal wave, may be its relatively fast (3.6 hour [6]) rotation period. For such a rapid rotation, the heated daylight side near perihelion has relatively little time to radiate its absorbed energy back into space during its short night-time interval.

References: [1] Binzel R. P. et al. (2001), *Icarus, 151* 139-149. [2] Mueller, M. et al. (2011), *Ast. J, 141,* 109-117. [3] Binzel, R. P., Rivkin, A. S., Thomas, C. A., DeMeo, F. E., Tokunaga, A., Bus, S. J. (2005), *LPSC XXXVI*, Abstract 36.1817. [4] de León, J. et al. (2011), *Astron. Astrophys., 530,* L12-L15. [5] Mottola, S. and Lahulla, F. (2000), *Icarus, 146*, 556-567. [6] Pravec P. et al. (2000), *Icarus,146,*190-203.

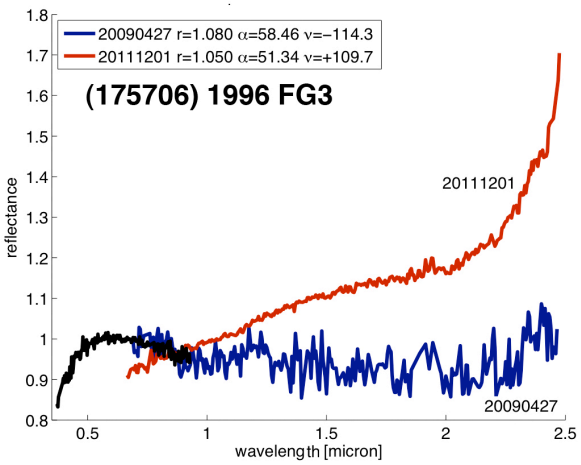

Figure 1: IRTF SpeX spectral measurements [3] of asteroid 1996 FG3 on two different dates, having minimal differences in their heliocentric distance (r, measured in AU) and solar phase angles (α, measured in degrees). Yet their spectral characteristics are distinctly different, notably the strong thermal flux present beyond 2 microns indicative of a significantly higher surface temperature. A key physical difference between the observations is the 2009 measurements are pre-perihelion, while the 2011 measurements are post-perihelion. (ν denotes the angular distance in degrees from perihelion as measured in heliocentric longitude.) We propose that the higher post-perihelion thermal flux and temperature are a consequence of the annual thermal temperature cycle of 1996 FG3 being dominant, rather than the diurnal cycle, as a consequence of the asteroid's known rapid rotation [5].