Detection of aspect-dependent thermal emission as a signature of near-Earth asteroid pole orientation

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Spin vectors are intimately related to the efficiency in which the Yarkovsky and YORP effects can change the orbital, rotational, and physical properties of minor planets (e.g., [1,2]) Despite the importance of spin vectors, only a few dozen asteroids have well constrained pole orientations. This is due to the years or even decades required to constrain spin vectors with astrometric, photometric or radar observations (e.g. [3,4,5]). Here we constrain the spin vector of the near-Earth asteroid (285263) 1998 QE_2 in a single apparition ($\sim$3 months) by monitoring its thermal emission as a function of phase angle (α).

We obtained near-infrared spectra of QE_2 between May and July of 2013 with SpeX at NASA's Infrared Telescope Facility. The low $\sim$ 6 % albedo of QE_2 [6] enabled the detection of thermal emission at near-IR wavelengths >2 µm. We modeled this thermal emission with the near-Earth asteroid thermal model, NEATM [7]. QE_2 is a well-characterized object with known albedo, diameter, spectral type, and absolute magnitude, thus the only free parameter in our NEATM models was the thermal beaming parameter η. We find a specific relationship between η and phase angle, which is fully consistent with a putative prograde rotation state [8] and a surface thermal inertia of $\sim$200 J m^{-2} s$^{-0.5}$ K^{-1} [9]; the latter is in line with expectations for $\sim$3 km asteroids like QE_2 [10]. This technique can be applied to low-obliquity near-Earth asteroids smaller than 5 km that are observable across a range of phase angles >30 degrees in a single apparition.

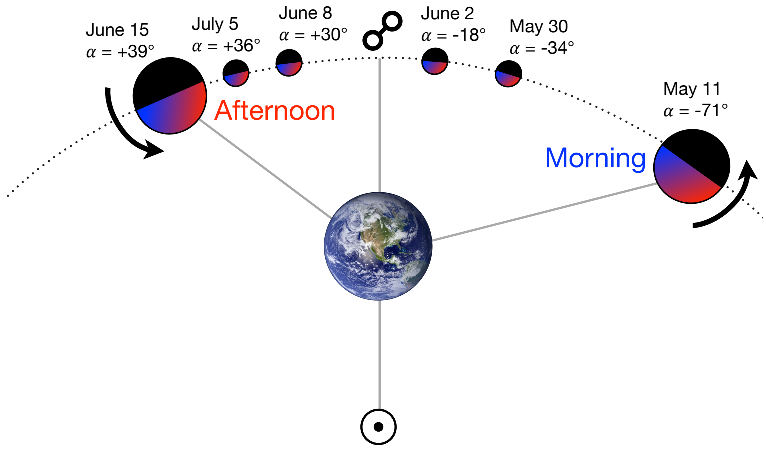

Figure: Opposition-centered orbital longitude of 1998 QE_2 during its 2013 apparition. The cartoons indicate illumination (black = night) and surface temperates (blue=cold, red=hot). The cartoons at maximal phase angles with prograde rotation indicated are larger to emphasize viewing of cooler morning temperatures pre-opposition and warmer afternoon temperatures post-opposition. Earth image: NASA/GSFC.

References: [1] Rubincam, D. P., 2000. Icarus 148, 2–11. [2] Bottke, W. F. et al., 2006. AREPS 34, 157–191. [3] Slivan, S. M., 2002. Nature 419, 49–51. [4] Taylor, P. A. and 11 co-authors, 2007. Science 316, 274–277. [5] Nugent, C. R. et al., 2012. AJ 144, 60. [6] Trilling, D. E. and 15 co-authors, 2010. AJ 140, 770–784. [7] Harris, A. W., 1998. Icarus 131, 291–301. [8] Springmann, A. and 7 co-authors, 2014. Lunar Planet. Sci. 45. Abstract 1313. [9] Delbo, M., 2004. Doctoral thesis, Freie Universitat Berlin. [10] Delbo, M. et al., 2007. Icarus 190, 236–249.