OBSERVATIONS OF PERIODIC COMET 2P/ENCKE: PHYSICAL PROPERTIES OF THE NUCLEUS AND FIRST VISUAL-WAVELENGTH DETECTION OF ITS DUST TRAIL.

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Introduction: We are conducting an observational program designed to determine the overall distributions of size, shape, rotation period, and surface characteristics of cometary nuclei [1]. Here, we present results from a study of the Jupiter-family comet 2P/Encke based on observations from Steward Observatory's 2.3m Bok Telescope at Kitt Peak. This comet has been observed extensively in the past and was one of the primary flyby targets of the recently failed CONTOUR mission [2].

Rotational lightcurve: Our observations include time-series *R* filter photometry obtained in September 2002, when the comet was at a heliocentric distance of 3.97 AU. Co-added images can be seen in Figure 1. From these data we have derived the rotation period and limits on the nuclear size and shape. The September rotational lightcurve is highly asymmetric - a feature also observed by Meech et al. [3] - with a periodicity of ~ 11.01 hours (Figures 2 and 3). In October 2002, we obtained 2 nights of broad-band *BVR* filter photometry, from which we shall investigate possible color variations with nucleus rotation. The mean apparent magnitude was 19.32 ± 0.03, which implies a mean effective radius of 4.05 ± 0.06 km, assuming an albedo of 0.05 and phase coefficient of 0.06 mag/deg. [4].

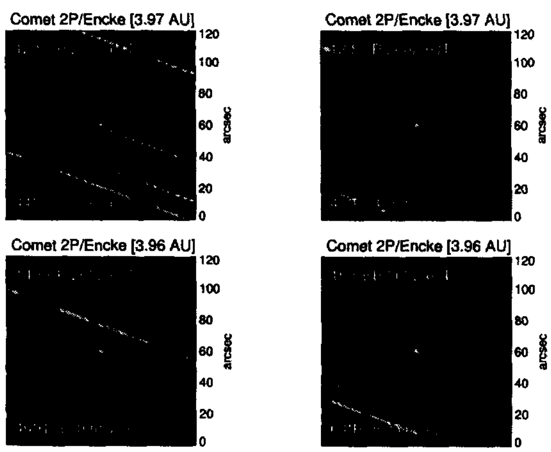

Figure 1. Co-added R band images from each of the four nights of observation in September 2002. The date of observation, number of exposures, total effective integration time, and the heliocentric distance is noted on each frame. No evidence for a resolvable coma was seen in any of these frames. Note that north is up and east is to the left.

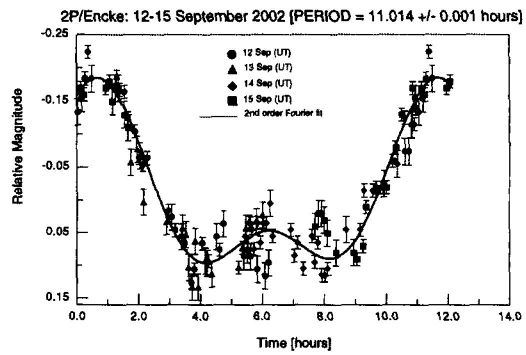

Figure 2. Rotational lightcurve for comet Encke obtained from 4 consecutive nights of observation in September 2002, at Steward Observatory's 2.3m Bok Telescope at Kitt Peak. A fourier analysis finds a best fit period period of 11.014 ± 0.001 hours.

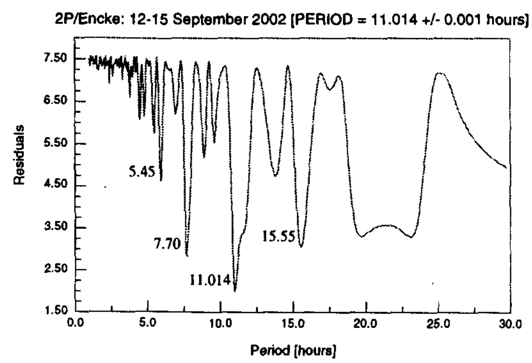

Figure 3. The resulting periodogram from 2nd order Fourier fits to the relative magnitudes. The feature at 11.014 ± 0.001 hours is the most prominent. The other solutions at 5.45, 7.70, and 15.55 hours were investigated and were shown to be non-viable when the relative magnitudes were phased assuming these periods.

Assuming that the brightness variations are purely shape induced, then the observed magnitude range of 0.36 ± 0.03 magnitudes implies a projected axial ratio of 1.39 ± 0.04 (neglecting possible phase effects). Note that the implied axial ratio from Meech et al. [3] is ~1.63. Knowledge of the shape and rotation period can allow us to place a lower limit to the bulk nucleus density ρ_b, i.e. the minimum density required in order to withstand centripetal disruption assuming negligible cohesive strength [5]. Applying this method to comet Encke leads to $\rho_b \geq 0.14$ g cm^{-3} (using our rotation period of 11.01 hours and the axial ratio found by Meech et al. [3]). Also see Figure 4.

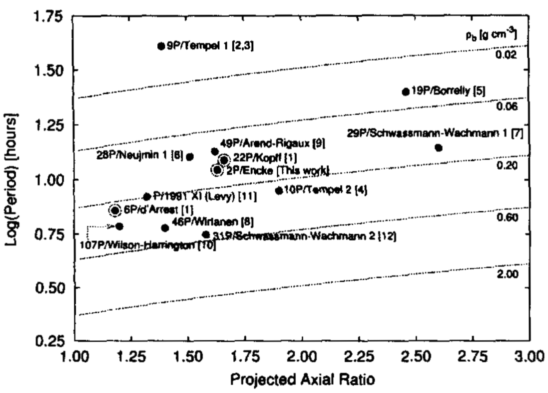

Figure 4. Shape and spin rate information derived from rotation lightcurves obtained via our program and those published in the literature. The inferred density lower limits are determined by their position on this plot. Lines of constant density for values of 0.02, 0.06, 0.20, 0.60, as 2.00 g cm^{-3} are shown for comparison. One can see that the density lower limit for comet 2P/Encke is typical for Jupiter-family comets. Figure adopted from Weissman et al. [6] (see references therein).

Dust Trial: We also report on our optical detection of comet Encke's dust trail. To date, the Encke dust trail has only been detected at IR wavelengths [7,8]. The first reported optical detection of a cometary dust trail was by Ishiguro et al. [9] for comet 22P/Kopff. They observed the Kopff dust trail in February 2002, and the trail was independently observed by Lowry and Weissman [1] in March 2001. Our visual detection of the Encke dust trail was achieved by co-adding 195, 300s *R* filter exposures acquired during four nights of continual observations (see Figure 5). The observations were obtained during excellent sky conditions in September 2002. Combining photometric measurements at visual and IR wavelengths will allow us to constrain the physical properties of the dust particles within the trail. That analysis is ongoing.

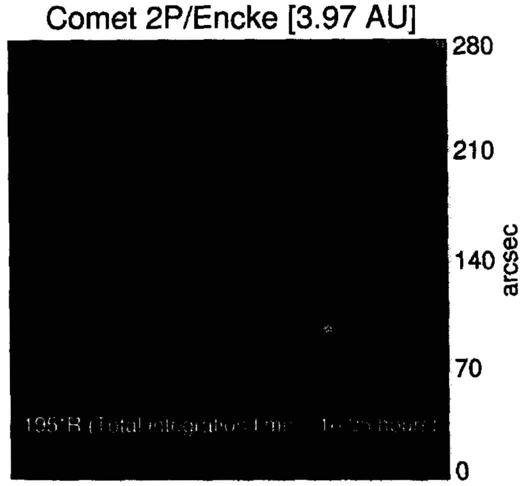

Figure 5. This image is a co-addition of 195, 300s *R* filter exposures obtained during four nights of continual observations in September 2001. This image is essentially the combination of the four images shown in Figure 3, with additional median filtering applied to remove the background stars. The trail can clearly be seen intersecting the comet. The heliocentric velocity vector – as projected onto the plane of the sky - lines up perfectly with the trail. Note that north is up and east is to the left.

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References: [1] Lowry S.C. and Weissman P.R. (2003) *Icarus*, in press. [2] Bell J.F., et al. (2000) *M&PS* 35, A23. [3] Meech K.J., Fernandez Y., and Pittichova (2001) *BAAS* 33, 1075 (abstract). [4] Fernandez Y.R. et al. (2000). Icarus 147, 145-160. [5] Luu J.X., and Jewitt D.C. (1992). AJ 104, 2243-2249. [6] Weissman P.R., Asphaug, E., and Lowry S.C. (2004) In *Comets II* (M.Festou et al. Eds.) University of Arizona, Tucson. Submitted. [7] Sykes M.V., and Walker R.G. (1992). *Icarus* 95, 180-210. [8] Reach W.T., Sykes M.V, Lien D., and Davies J.K. (2000) *Icarus* 148, 80-94. [9] Ishiguro M. et al.(2002) AJ 572. L117-120.