5088 TANCREDI: ROTATION PERIOD AND PHASE COEFFICIENTS

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The main-belt asteroid 5088 Tancredi was observed during a period of 42 days close to the 2009 opposition. The data were collected with a clear filter on 15 different nights. R-magnitudes were calculated using the MPOSC3 Catalog. The observations covered a range of phase angles from 0.35° to 16°. The phase coefficients in the H-G system (R-mag) are: HR = 12.36 HR = 12.36 [12.30, 12.43]; G = 0.058 [–0.036, 0.153], with 95% confidence range presented within the brackets. Based on the low value of G, the asteroid can be tentatively classified as a C-type asteroid. A precise estimate of the rotation period is computed as P = 5.05909 ± 0.00014 h. The amplitude is A = 0.31 mag.

The main-belt asteroid 5088 Tancredi was observed during the 2009 opposition, one of the more favorable in recent years. Perihelion passage and opposition occurred in 2008 Oct. 12 and 2009 Jan 15, respectively. The asteroid reached a minimum apparent magnitude of R~15.5, allowing us to obtain an acceptable lightcurve with our 35-cm telescope. We could find no photometric data of this asteroid published in the literature.

The observations were done at the Observatorio Astronómico Los Molinos (IAU code 844), in the north of Montevideo, the capital of Uruguay, and so under moderately-strong light pollution conditions. Images were taken on 15 different nights from 2009 Jan 15–Feb 26, spanning a period of 42 days. The observational details are given in Table I. We used a 0.35-m f/5.08 Newtonian (modified Cassegrain) with an SBIG ST-7 CCD camera and clear filter. The field of view was 16.5x11 arcminutes with a scale of 1.29 arcsec/pixel. The images were acquired with *Maxim DL*. Bias and dark frames were collected every night, but dome flat fields were collected on only a few nights. The images were calibrated using the *Maxim DL*. The photometric reduction was done with *MPO Canopus* V10. The photometric reference catalog was MPOSC3, provided with MPO software, which includes a large subset of the Carlsberg Meridian Catalog (CMC-14) as well as the Sloan Digital Sky Survey (SDSS). Only stars that are about the same color as the Sun were used as comparison stars. The values of the R-mag were used for reference.

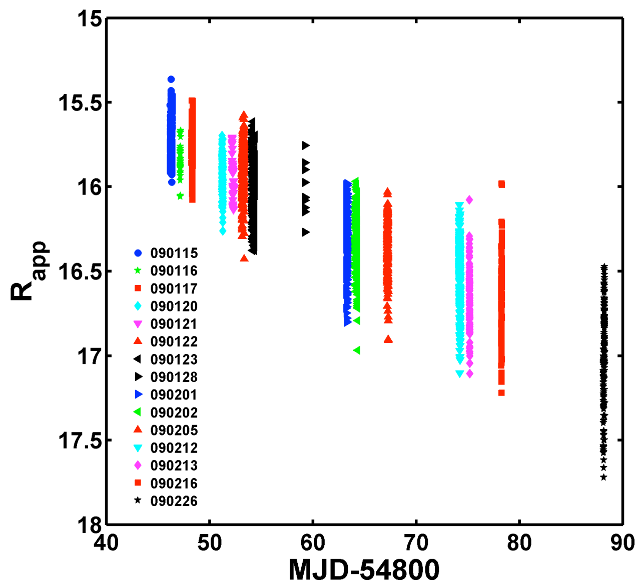

Figure 1. The apparent R magnitude as a function of date (Modified Julian Date – 54800).

Figure 1 shows the apparent R magnitude plotted as a function of date. As seen in Table I, the phase angle was increasing over the span of observations. This and the increasing distance from Earth explain the decline in apparent brightness over time. We computed the median value of the apparent R magnitude each night. These values were corrected for heliocentric and geocentric distance to obtain the reduced magnitude R(1,1,α). The results are listed in Table I and plotted as a function of the phase angle (α) in Figure 2. The phase function adopted by the IAU (Bowell *et al.*, 1989) was

UT Date	R.A.	Dec.	r	Δ	α	δT	N	R(1,1,α)	σ_R	δR
2009 Jan 15	07 47	+22 02	2.655	1.672	0.33	4.4	257	15.71	0.004	0.36
2009 Jan 16	07 46	+22 04	2.656	1.673	0.60	0.7	34	15.83	0.024	0.24
2009 Jan 17	07 45	+22 06	2.657	1.674	1.01	3.3	205	15.79	0.008	0.35
2009 Jan 20	07 43	+22 12	2.658	1.678	2.34	3.2	171	15.89	0.008	0.29
2009 Jan 21	07 42	+22 14	2.659	1.680	2.79	3.4	39	15.91	0.018	0.35
2009 Jan 22	07 41	+22 16	2.660	1.683	3.23	5.5	252	15.90	0.006	0.38
2009 Jan 23	07 40	+22 18	2.660	1.686	3.68	6.1	327	16.01	0.007	0.46
2009 Jan 28	07 36	+22 26	2.664	1.703	5.86	0.2	10	16.06	0.081	0.40
2009 Feb 01	07 33	+22 33	2.666	1.722	7.54	3.2	203	16.30	0.012	0.46
2009 Feb 02	07 32	+22 34	2.667	1.728	7.95	4.7	248	16.29	0.010	0.41
2009 Feb 05	07 30	+22 38	2.669	1.746	9.15	2.2	152	16.34	0.015	0.42
2009 Feb 12	07 26	+22 44	2.675	1.796	11.75	1.8	185	16.48	0.020	0.53
2009 Feb 13	07 25	+22 45	2.675	1.804	12.10	1.1	122	16.67	0.027	0.48
2009 Feb 16	07 24	+22 47	2.678	1.829	13.11	1.4	122	16.68	0.035	0.65
2009 Feb 26	07 22	+22 48	2.686	1.926	16.04	2.9	144	16.99	0.027	0.80

Table I - Observation details. The ephemerides are computed at 03h UT of the corresponding day. r - heliocentric distance (AU), Δ - geocentric distance (AU), α - phase angle (º), δT - time interval of the observation (hr), N - number of data points, R(1,1, α) - median value of the distance reduced R-mag. for the night, σ_R - error of the mean value (computed as the square root of the sum squares of the individual errors divided by N), δR - magnitude range during the night (computed as the difference between the magnitude in the 90% percentile minus the one in the 10% percentile of the sorted R-mag).

fitted to the R(1,1,α) magnitudes using the nonlinear least-squares *fit* function in *Matlab R2008b*.

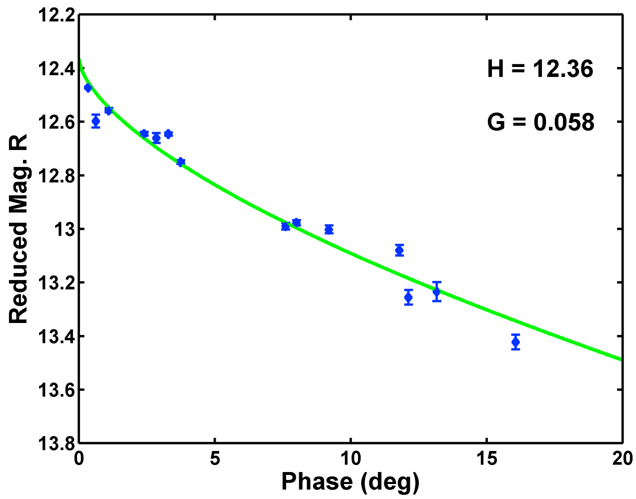

Figure 2. Reduced magnitude R(1,1,α) vs. phase angle (α). The green line is the least-squares fit to the data.

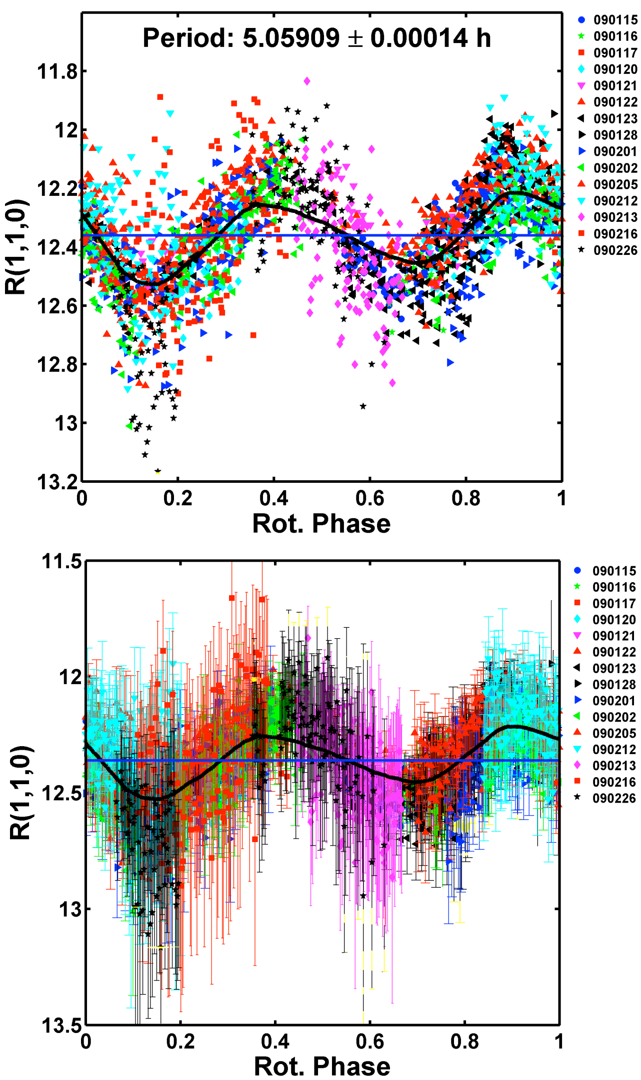

Figure 3a (top) shows the data phased to a period of 5.05909 h without error bars. Figure 3b (bottom) includes the error bars.

From our analysis, we derived values of H_R = 12.36 [12.30, 12.43]; G = 0.058 [–0.036, 0.153]. The lower and upper 95% confidence bounds are presented between brackets. Note that the lower bound of G is an unrealistic negative value. A value of G = 0.058 is typical of a low-albedo C-type asteroid (Lagerkvist and Magnusson 1990). 5088 Tancredi has a semimajor axis a = 3.1 AU and a low eccentricity, e = 0.16. This tentative classification of 5088 Tancredi as a C-type asteroid is in agreement with the fact that, in the outer region of the main belt where the object is located, C-type asteroids prevail (Gradie and Tedesco 1982, Pieters and McFadden, 1994).

Period analysis was performed using *MPO Canopus*, which incorporates the Fourier analysis algorithm (FALC) developed by Harris (Harris *et al.*, 1989). We corrected each observation for the phase effect using the value of G we obtained. We then combined the data of the 15 nights to obtain a rotation period of 5.05909 ± 0.00014 h and a time of minimum of JD 2452846.6867. The phased plot is presented in Figures 3a and 3b without and with magnitude error bars, respectively. A mean curve is computed as the running mean with a window of 251 points. In order to compute the mean values at the edge of the plot, the data points are recycled before rotational phase 0 and after 1. A horizontal line at R(1,1,0) = 12.36 is drawn in each plot. The maximum amplitude of the mean curve is A = 0.31 mag.

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References

Bowell, E., Hapke, B., Domingue, D., Lumme, K., Peltoniemi, J., and Harris, A. (1989). "Application of Photometric Models to Asteroids." in *Asteroids II* (R. Binzel, T. Gehrels, M. Matthews, eds.) University of Arizona Press, Tucson. p.524.

Gradie, J. and Tedesco, E. (1982). "Compositional structure of the asteroid belt." *Science* **216**, 1405-1407.

Harris, A.W., Young, J.W., Bowell, E., Martin, L. J., Millis, R. L., Poutanen, M., Scaltriti, F., Zappala, V., Schober, H. J., Debehogne, H, and Zeigler, K. (1989). "Photoelectric Observations of Asteroids 3, 24, 60, 261, and 863." *Icarus* **77**, 171-186.

Lagerkvist, C.-I. and Magnusson, P. (1990). "Analysis of asteroid lightcurves. II - Phase curves in a generalized HG-system." *Astron. Astrophys. Suppl. Ser.* **86**, 119-165.

Pieters, C. and McFadden, L. (1994). "Meteorite and Asteroid Reflectance Spectroscopy: Clues to Early Solar System Processes." *Annual Review of Earth And Planetary Sciences* **22**, 457-497.