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Goldstone Radar Imaging of Near-Earth Asteroid (214869) 2007 PA8

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Abstract

We report Goldstone radar (8560 MHz, 3.5 cm) observations of potentially hazardous asteroid (214869) 2007 PA8. 2007 PA8 approached within 0.043 AU (17 lunar distances) on November 5, 2012 when it was the target of an extensive radar observing campaign. Goldstone's new chirp system imaged the asteroid with 3.75 m range resolution and placed thousands of pixels on its surface. The images suggest that 2007 PA8 is an elongated, asymmetric object with a slow, ~4 day rotation period.

1. Introduction

Asteroid 2007 PA8 was discovered by LINEAR on August 9, 2007. It has an unusual orbit that resembles that of a Jupiter-family comet (Tisserand parameter T= 2.947). Among the ~370 NEAs detected by radar, there are currently only 20 objects with T < 3.0, the classical threshold to distinguish asteroids from comets. Objects in the near-Earth population that resemble comet nuclei are of high science interest because of their dynamical history, their chemical composition, and because they could be a potential reservoirs of volatiles. Visible-near infrared spectra obtained by [1] and [2] classified 2007 PA8 as an Xc-type and S-type object, respectively. [1] also estimated a rotation period of 95.1± 3.4 h from the photometric lightcurve.

2. Observations

We observed 2007 PA8 on 16 days between Oct 16 and Nov 13, 2012 at NASA's 70-m Deep Space Network antenna at Goldstone, California, during which asteroid traversed ~120 deg across the sky. We collected both continuous wave (CW) echo power spectra as well as delay-Doppler images. The delay-Doppler images achieved range resolutions between 3.75 m and 150 m, depending on the asteroid's distance from Earth (Table 1). The radar images reveal slow rotation, with features that repeat about once every four days, which is consistent with the rotation period obtained from the lightcurves. Figure 1 shows images from four days that sample different orientations. The echo shows angular features on Oct 31 (feature A), facets on Nov 2 and on Nov 3 (features B and C), and a hint of a concavity, approximately several hundred meters across, on Nov 5 (feature D). The maximum and minimum visible extents (Table 1) varied between ~525 m and ~1148 m and the Doppler bandwidths varied between 0.88 Hz and 1.5 Hz. If 2007 PA8 is a principal axis rotator, then the day-to-day bandwidth changes (which are sensitive to asteroid's elongation as well as subradar latitude changes due to sky motion), suggest that the pole-on elongation is ~1.5. The average visible extent in the delay-Doppler images is ~784 m, which can be used as a zeroth-order approximation of the radius. This size estimate, in combination with the average Doppler bandwidth of 1.19 Hz, suggests a rotation period in the realm of 131 hours x cos (δ) (derived from Eq. 1). 131 hours period is slower than the radar images and lightcurves [1] indicated, which suggests that the subradar latitude δ must have been several tens of degrees off the equator on at least some of the observing days.

3. Figures

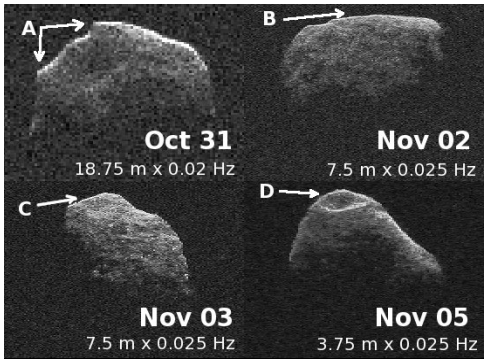

Figure 1: Selected Delay-Doppler images of 2007 PA8. Time delay increases from top to bottom and Doppler frequency increases from left to right. The scale of each frame is 1.5 km x 2 Hz.

4. Tables

Table 1: Distance from Earth at the time of observations, delay-Doppler resolutions, visible extent in time delay, and Doppler broadening. 1μs=150 m

Date	Dist. AU	Res. μs x Hz	Del. μs	B Hz
Oct 16	0.139	1.0 x 0.120	600	1.56
Oct 17	0.132	1.0 x 0.060	600	1.08
Oct 18	0.126	1.0 x 0.060	600	1.38
Oct 19	0.120	0.5 x 0.060	525	1.26
Oct 28	0.068	0.125 x 0.016	806	1.09
Oct 29	0.063	0.125 x 0.018	694	1.46
Oct 30	0.059	0.125 x 0.020	1031	1.00
Oct 31	0.055	0.125 x 0.020	938	1.32
Nov 2	0.048	0.05 x 0.025	728	1.18
Nov 3	0.046	0.05 x 0.025	765	0.88
Nov 5	0.043	0.025 x 0.028	848	1.08
Nov 6	0.044	0.025 x 0.028	994	0.89
Nov 8	0.047	0.05 x 0.025	1148	0.95
Nov 11	0.056	0.125 x 0.020	619	1.50
Nov 12	0.061	0.125 x 0.019	844	1.01
Nov 13	0.065	0.125 x 0.018	806	1.46

5. Equations

The Doppler broadening (or bandwidth) of an echo is given by:

$$B = \frac{4\pi D}{\lambda P}\cos(\delta) \qquad (1)$$

where B is the bandwidth, D is the object's maximum breadth in the plane of the sky perpendicular to the spin vector, λ is the radar wavelength (3.5 cm at Goldstone), P is the rotation period, and δ is the subradar latitude.

6. Summary and Conclusions

Is 2007 PA8 an inactive Jupiter-family comet? Although its orbit is cometary, there are no reports of cometary activity for this object. [1] reports that 2007 PA8 is optically dark, but the 1.6 km diameter suggested by the radar observations requires an optical albedo that is too bright for any of the optically-dark spectral classes. Given that all the comet nuclei imaged to date have been optically dark, we conclude that 2007 PA8 is not a comet.

Acknowledgements

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References

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[2] Godunova, V., et al., 2013. Spectrophotometric studies of near-Earth asteroids at the Terskol Observatory. Vol. 15, EGU2013-13797-1.