Photometric Observations of 1999 KX4 and Astrometric Observations of 2013 PY6.

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Abstract

As a member of the Table Mountain Observatory's Photometry and Astrometry team, data were collected of Near-Earth Object (NEO) 1999 KX4 (13199) and the NEO 2013 PY6 (P107QiZ). Photometric data acquisition of 1999 KX4 was performed following an observing model established by Dr. Michael Hicks to secure flat field images, Landolt standard fields and time resolved BVRI imaging. The data on 1999 KX4 were gathered over six nights then analyzed to establish period rotation, phase curve, and phase coefficient. Astrometric data were acquired over one night of NEO 2013 PY6 and reported to the Harvard Smithsonian Minor Planet Center in an effort to confirm the objects status as a new near-Earth object. Additionally, the data were analyzed to establish its orbit through the solar system.

Introduction

Asteroids are abundant in our solar system as a result there are three major classifications of near earth asteroids: Amor, Apollo, and Aten. Amor asteroids are defined to have orbits that approach Earth's orbit, but never cross. Amor asteroids orbit between Mars and the Earth. Apollo asteroids are defined as having orbits that cross Earth's orbit, and spend most of their orbital time outside Earth's orbit. Aten asteroids are defined to have orbits that cross Earth's orbit, and spend most of their orbital time inside Earth's orbit. Near Earth Objects are defined to have a perihelion distance less than 1.3 astronomical units (AU) from our Sun.

The Summer of 2013 consisted of gathering observations of 1999 KX4 and 2013 PY6 at the Jet Propulsion Laboratory Table Mountain Facility located in the Angeles National Forest near Wrightwood, CA. An Astro-Mechanics 0.6m, f/16 Ritchey-Chretien reflector on a German off-axis equatorial mount equipped with a glycol cooled 2K Spectral Instruments 850S CCD camera were used.

Observations

Broadband photometry was used to determine the characteristics of 1999 KX4 by using an observing model designed by Dr. Michael Hicks. The capture of bias/dark images, landolt standard field images, and sky flat field images, with color B,V,I,R filters were used to determine the rotational period, solar phase angle, and phase coefficent as a function of the log10 of albedo. Figure 1 shows a raw field of 1999 KX4, and figure 2 shows a finalized field. The rotational period of 1999 KX4 was based on the relative magnitude over time. Figure 3 shows the rotation period of 1999 KX4. The inconsistency in each observation makes the determination of period impossible, and what is identified in the figure seems to indicate the rotation of a tumbling asteroid. If an asteroids rotation is too rapid it could be caused by other components bound together, or fragment derived from cratering or collisional destruction of a much larger asteroid.[9] 1999 KX4 rotational period is best described as a monolithic tumbler. A rotator with a superfast period, that cannot be held together by self-gravitation and must be a coherent body with a non-zero tensile strength.[8] The solar phase angle was calculated by the approximation of an HG function.[3] Figure 4 shows the phase curve of 1999 KX4.

The inconsistency at large solar phase angles could not be explained. The phase coefficient was

dependent on the slope of the linear phase curve of different asteroid albedos.[3] Figure 5 shows the phase coefficient of 1999 KX4. The plots are interpreted as surface mineralogy. The grey plots are carbon and organic rich silicate asteroids. The green plots are metal, or traces of silicate asteroids. The blue plots are shock-darkened silicate asteroids. The red plots are metal, olivine, and pyroxene asteroids. Finally the yellow plots are enstatite asteroids. 1999 KX4 was calculated to fit as a red plot with an approximation of an metal, olivine, and pyroxene asteroid. Figure 6 shows spectroscopic observations of 1999 KX4 from Palomar Observatory. From the observations 1999 KX4 was described to be an SQ type asteroid. An SQ asteroid is defined as an asteroid with a steep slope less than 0.7 μm and a large round hump greater than 0.7 μm.[4] Confirming that 1999 KX4 is a metal, olivine, pyroxene asteroid. Figure 1 shows the orbital path of 1999 KX4 from the Minor Planet Center.[1] The asteroids perihelion distance from the Sun was 1.03 AU. Figure 7 also shows that the asteroid crosses Earth orbit twice in a singe period.

Using the Minor Planet Center's Confirmation Page, astrometry data were used to determine the position of 2013 PY6. Figure 8 shows a time interval used to capture a minimum of 50 reference/background stars for an astrometric fit. With the use of Astromtrica as an astrometry tool an fit was found, and the right ascension and declination was determined. A comparison to JPL Horizons was done, and the residuals were calculated. The residuals were well over 2, which confirms 2013 PY6 was not a new asteroid nor was it a Near Earth Asteroid. Figure 9 shows the orbital path of 2013 PY6 from the Minor Planet Center.[2] The figure shows that the asteroids path is clearly in the main asteroid belt, and comes no-where near earths orbital path.

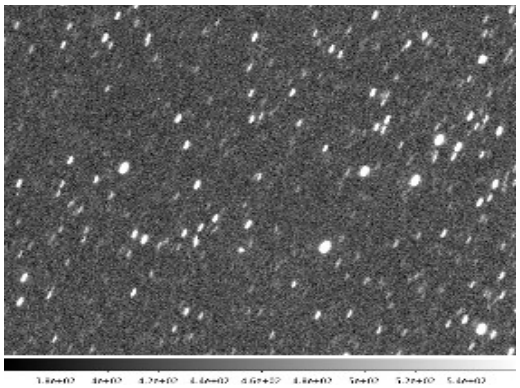

Figure 1: A raw image of asteroid 1999 KX4.

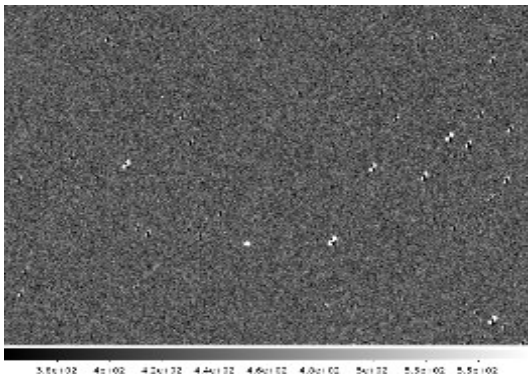

Figure 2: A final image of 1999 KX 4.

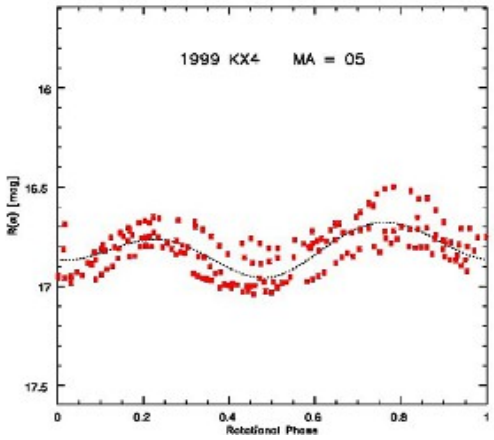

Figure 3: Rotational period of 1999 KX4.

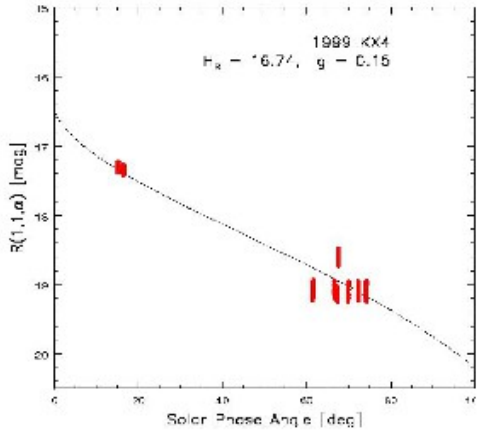

Figure 4: Phase Curve of 1999 KX4.

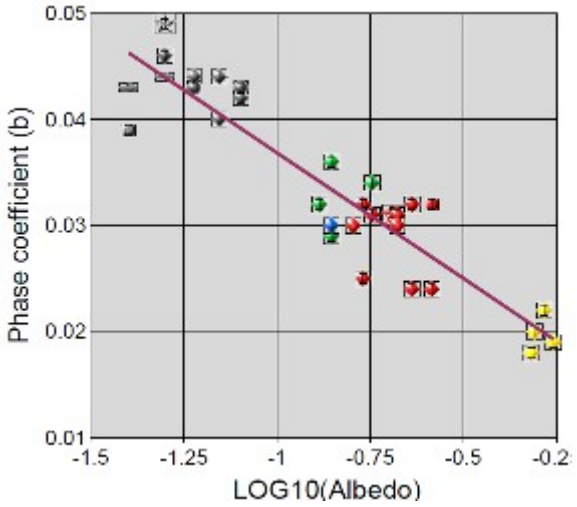

Figure 5: Albedo as slope coefficient of 1999 KX4.

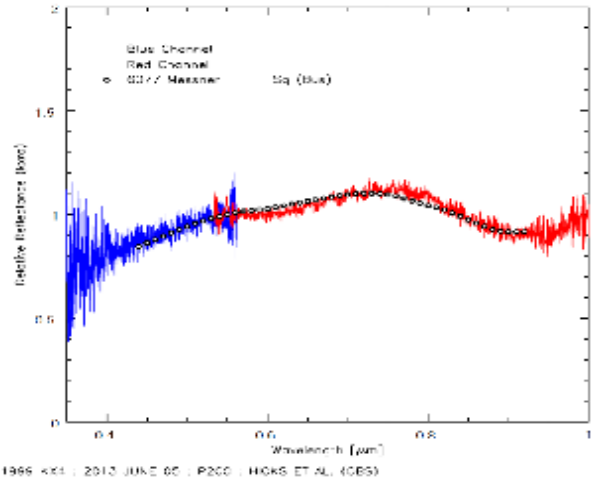

Figure 6: Spectroscopic observations from Palomar Observatory.

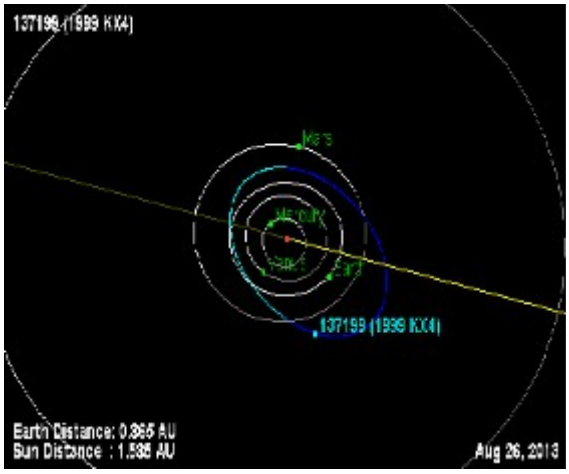

Figure 7: Orbital path of 1999 KX4.

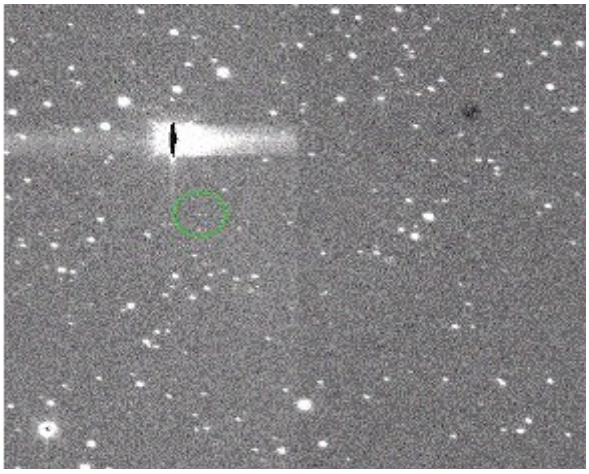

Figure 8:Raw image of 2013 PY6.

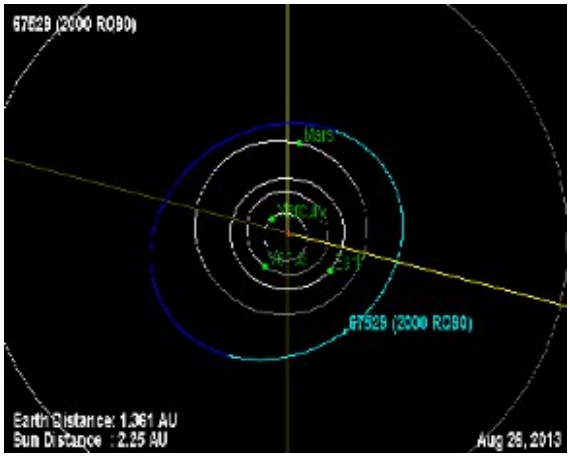

Figure 9: The orbital path of 2013 PY6.

Conclusion

The observations of both asteroids over the Summer were successful. The data gathered helped explain the characteristics of 1999 KX4, and the positions of 2013 PY6. Following Dr. Michael Hicks' observing model the rotation period of 1999 KX4 was indeed a tumbling asteroid. An approximate taxonomy determined by the calculations of a slope coefficient indicated that 1999 KX4 was a metal rich asteroid, and the observations from Palomar Observatory agree.

The data gathered on 2013 PY6 explained that moving objects are abundant in our nights skies. The residuals should have been taken into considerations before submission to Harvard Smithsonian Minor Planet Center. Although the observations on 2013 PY6 didn't not confirm that it was a new asteroid it did teach me a lot.

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