Orbital Shapes of Asteroids in Cometary Orbits based on 0.7m Telescope Imaging

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Abstract. The study of orbital elements of Asteroids in Cometary Orbits (ACOs) is based on images taken by a 0.7-m telescope to find positions of asteroids and calculate their orbital elements. This work focuses on variation of positions and orbital shape of an asteroid, 1667Pels, which is obtained by analyzing orbital elements and minimum orbital intersection distances. Each observation, those parameters are affected by the gravity from Jupiter on ACOs. The accuracy of single site data was calibrated by comparing the result from this work to other observations in Minor Planet Center database.

1. Introduction

Asteroids are members of minor planet group. Some of their movements are affected by giant planets, especially Jupiter, which make orbits of asteroids highly variable. The three-body problem is the major case for discussion about position of planet and its satellite. For asteroid, it is a special case that is called restricted three-body problem [3] because it has infinitesimal mass and moves in the gravitational field of the sun and giant planets. Solution of restricted three-body problem is [3]

$$v^2 = x^2 + y^2 + \frac{2(1-\mu)}{r_1} + \frac{2\mu}{r_2} - C \tag{1}$$

Where v is the speed of the infinitesimal mass. x and y are position of the mass. r_1 and r_2 are positioning vectors of the mass, μ is mass of secondary body and $1-\mu$ is mass of primary body C is Jacobi's integral parameter, μ is a planet and $1-\mu$ is the Sun. C is Jacobi's integral parameter.

Semi-major axis, eccentricity and inclination of infinitesimal mass can be found based on C parameter in this work. C parameter is used to describe the orbit shape of an asteroid. After close approaching to a giant planet, r_1 and r_2 will be larger. Jacobi's integral can be approximated in term of orbital elements as following [3].

$$\frac{1}{a} + 2\sqrt{a(1-e^2)}\cos i = C \tag{2}$$

a is semi-major axis. e is eccentricity. i is orbit's inclination. Under perturbation by giant planet, which is Jupiter for this work, the orbital elements of asteroid should be changed, while C is still a constant.

As a result, if a_1, e_1, i_1 are orbital elements from first observation and a_2, e_2, i_2 are from second observation, relation between two observations must be [3].

$$\frac{1}{a_1} + 2\sqrt{a_1(1-e_1^2)}\,cos\,i_1 = \frac{1}{a_2} + 2\sqrt{a_2(1-e_2^2)}\,cos\,i_2 \tag{3}$$

This criterion is called Tisserand's criterion, that which is used to identify new object from observation. In our observation, this criterion is transformed into Tisserand's parameter for Jupiter by[3].

$$T_j = \frac{a_j}{a} + 2\sqrt{\frac{a}{a_j}(1-e^2)}\,cos\,i \tag{4}$$

where a_j is Jupiter semi-major axis . The aim of this work is to study the variation of positions and orbital elements of asteroids, 1667 Pels, which have $T_j < 3$ at Doi Inthanon Thailand that locates near Earth's equator.

2. Observation and Data Analysis

Astrometric data is position of object in equatorial coordinate, including right ascension (RA) and declination (Dec). Images of asteroids ware taken by 0.7 telescope at Thai Robotic telescope Thai Airforce observatory (TRT-AF). Each image was analyzed by using World Coordinate System (WCS) software and comparison blinking to find asteroid in each image that take from the same position of sky. Continuous identify asteroid in the image by *Astrometrica* software. RA and Dec of three observations were calculated to obtain orbital elements by Gauss method [5] with Charon software.

For accurate positioning, the observation must be calibrated by comparing our results with data from other observatories. This procedure can be done by registering TRT-AF to Minor Planet Center (MPC) to have observatory code.

3. Results

Three Asteroid images were analyzed by Blink method to find its coordinate and identify its name. Finally image's parameters were be obtained by *Astrometrica* software, as seen in Figure 1 and Table 1. for an asteroid, 1667 Pels.

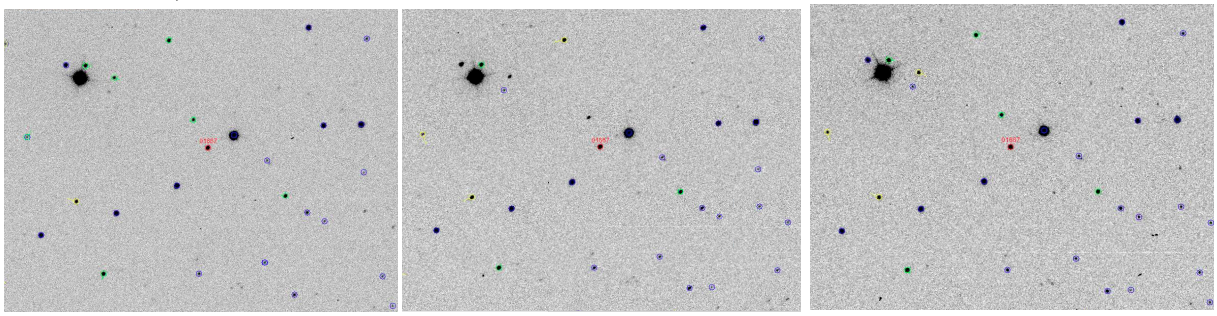

Figure 1 *Astrometrica* software can identify asteroid by blinking the images and report some parameters about position error of asteroid, which is 1667 Pels, in term of dRA and dDe. Reference stars are used to identify asteroid's name.

Table 1 Information and results from the analysis for an asteroid, 1667 Pels, by *Astrometrica* software corresponds to Figure 1.

Asteroid Information	
RA	14hr 45m 20.6s
DEC	-8° 53′ 58.5″
Magnitude (V)	15.3
PSF-Fit	
x position (pixels)	1288.08
y position (pixels)	1147.66
SNR	17.5
Flux (counts)	5179
FWHW (arcmin)	2.6
Fit RMS	0.098

In order to correctly register the information to the on-line data base, TRT-AF's observatory code is needed to be informed. The sample of registered information is shown in Table 2.

Table 2 Information registered to MPC consists of observation's data and observatory information

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CON National Astronomical Research Institute of Thailand. Chiangmai
Thailand [Sittiporn@narit]
OBS S. Dueantakhu
MEA S. Dueantakhu
TEL 0.7-m f/6.5 Planwave CDK700 Telescope +ProLine PL16803 CCD
Camera ACK MPCReport file updated 2017.03.02 23:03:39
AC2 Sittiporn@narit.or.th
NET UCAC-4
COM New observatory code request
COM Purpose name is TRT-AF Observatory
COM Long 98 29 7.9 E, Lat 18 35 23.6 N, Alt 2540, Google Earth

00244      C2017 02 28.67760 08 32 36.49 +14 18 34.2         17.0 V
00244      C2017 02 28.72573 08 32 38.18 +14 18 21.1         16.6 V
00244      C2017 02 28.76866 08 32 39.74 +14 18 09.7         16.6 V
00244      C2017 03 01.60961 08 32 03.76 +14 08 05.4         17.7 V
00244      C2017 03 01.66024 08 32 05.22 +14 07 45.2         17.7 V
00244      C2017 03 01.71231 08 32 06.70 +14 07 24.7         17.6 V
00471      C2017 02 28.69087 10 36 27.95 +30 54 24.3         11.2 V
00471      C2017 02 28.73454 10 36 25.48 +30 54 36.4         11.2 V
00471      C2017 02 28.77868 10 36 23.00 +30 54 48.5         11.1 V
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4. Discussion

Many asteroid ware observed to test telescope pointing and adding coordinate to images by *Pinpoint astrometry* software. Accuracy of telescope pointing is under 0.6 arc minute and time accuracy is less than 0.1 micro second. For adding coordinate, small SNR image was to identify asteroid that move between each image and report position in MPC form but calculation of orbital elements by *FindOrb* software are very different form MPC database by hundreds to thousands arc seconds. In order to improve our calculation, first, more observations should be performed to provide more data with longer time span. This improvement is necessary for Gauss method [4][5]. On the other hand, we are correcting the calculation by improving the calibration method, based on the telescope's position angle. This method will improve the uncertainty of RA and Dec determination for short-time observations, e.g. within 1 or 2 days.

5. Conclusions

In this study, we employed the images from direct observations for 1667 Pels to obtain its updated orbital elements. The results of this work are under process of registration to Minor Planet Center (MPC). With improved observational and data analysis techniques, as mention in session 4, we expect to register more targets to the database. For future work, we plan to collect more observational data for asteroids with Tj<3, for example 3552 Don Quixote, 944 Hidalgo, 6144 Kondojiro, 7092 Cadmus, 2000 OG44, 20898 Fountainhills, 306367 Nut, 1973 NA and 1998 SO10.

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