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]

\[ \dot{u}^2 = x^2 + y^2 + \frac{2(1-\mu)}{r_1} + \frac{2\mu}{r_2} - C \]  

Where \( \dot{u} \) 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, \( \mu \) is mass of secondary body and \( 1 - \mu \) is mass of primary body \( C \) is Jacobi's integral parameter, \( \mu \) 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].

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

\( a \) 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].

\[
\frac{1}{a_1} + 2\sqrt{a_1(1 - e_1^2)} \cos i_1 = \frac{1}{a_2} + 2\sqrt{a_2(1 - e_2^2)} \cos i_2
\]  

(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].

\[
T_j = \frac{a_j}{a} + 2 \frac{a}{a_j} (1 - e^2) \cos i
\]

(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 were 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.
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

| 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        |

4. Discussion
Many asteroid were 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 Kendojiro, 7092 Cadmus, 2000 OG44, 20898 Fountainhills, 306367 Nut, 1973 NA and 1998 SO10.

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