Asteroid 2024 PT5: Earth's „satellite" for two months

© A.A. Martyusheva, A.V. Devyatkin, S.N. Petrova

Pulkovo Astronomical Observatory, Russian Academy of Sciences,
196140 St. Petersburg, Russia
e-mail: alex.mart13@gmail.com

Received April 27, 2025
Revised July 9, 2025
Accepted July 14, 2025

Asteroid 2024 PT5 was captured by Earth's gravitational field as a result of its approach and, while in geocentric orbit, became the so-called „satellite" of the Earth for two months. Observations of asteroid 2024 PT5 were conducted with the MTM-500M telescope of the Pulkovo Observatory as part of the program for studying near-Earth objects, which helped to refine the elements of the asteroid's orbit, study its orbital evolution, and assess the impact of non-gravitational effects and the period of axial rotation.

Keywords: near-Earth asteroids, astrometry, orbital evolution, non-gravitational effects.

DOI: 10.61011/TP.2025.12.62479.219-25

Asteroid 2024 PT5 with a size of about 10 m [1,2] was discovered on August 7, 2024, by the South African Asteroid Terrestrial-impact Last Alert System (ATLAS) in Sutherland the day before its approach to the Earth at a distance of about $5.7 \cdot 10^8$ m. It is a member of the Apollo family, whose orbits intersect the Earth's orbit from the outside, and despite a number of successive close approaches to the Earth and the Moon, it is not a potentially hazardous object due to its small size.

On September 29, 2024, this asteroid was captured by Earth's gravity and was in a geocentric orbit until November 25, 2024, becoming the so-called „satellite" for 57 days.

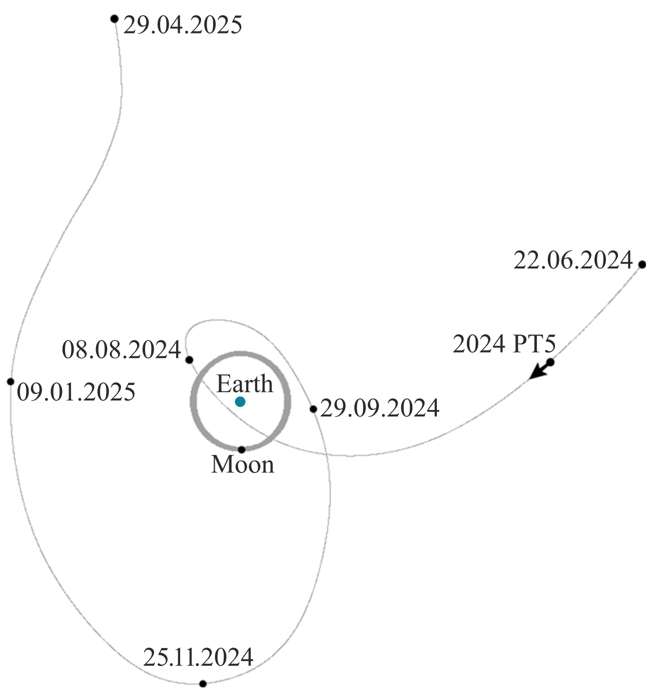

Figure 1. The orbit of the asteroid 2024 PT5 in the time interval 22.06.2024–29.04.2025. View from the north pole of the ecliptic.

Table 1. Close approaches of the asteroid 2024 PT5 in 2024–2055

Date, time (TDB)	Object of approach	Minimum distance (AU)
August 8, 2024, 8:00 p.m.	Earth	0.00379
August 12, 2024, 11:41 p.m.	Moon	0.00331
January 9, 2025, 02:11 a.m.	Earth	0.01204
January 12, 2025, 12:21 p.m.	Moon	0.00970
November 8, 2055, 4:30 p.m.	Earth	0.03578

Thus, asteroid 2024 PT5 made a horseshoe-shaped turn around the Earth, without making a single complete revolution due to leaving the sphere of gravitational influence of the Earth (Fig. 1). When the asteroid 2024 PT5 came out of resonance with the Earth on January 9, 2025, at a distance of $1.8 \cdot 10^9$ m, it moved back into a heliocentric orbit until its next return on November 8, 2055. This time, the approach will take place at a distance of about $5.4 \cdot 10^9$ m. The close approaches of the asteroid 2024 PT5 in 2024–2055 [3] are listed in Table 1.

This phenomenon cannot be called unique, but it is of interest for research due to its rarity. In addition, the gravitational capture of such objects for study in near-Earth orbit may be interesting from the point of view of mining. According to the hypotheses presented in Ref. [1,2], the asteroid 2024 PT5 may be a fragment of lunar rock and has a natural origin. Observations as part of the near-Earth object study program were conducted on the MTM-500M telescope [4] of the Pulkovo Observatory, located at the Kislovodsk Mountain Astronomical Station, and 28 reliable astrometric positions of the asteroid 2024 PT5 were obtained. Astrometric and photometric processing of CCD frames was performed using the software package Apex-II [5]; the Gaia catalog DR3 was used as a reference. Ephemeris support for observations, their processing and

Table 2. Refinement of the orbital elements of the asteroid 2024 PT5 for the epoch JD 2460600.5

Orbits elements	Initial (from the MPC catalog)	Improved	Correction	Variance
M, (°)	323.677260	323.677291	0.000031	0.0000089
ω, (°)	116.248430	116.248410	−0.000020	0.0000149
Ω, (°)	305.572350	305.572352	0.000002	0.0000066
i, (°)	1.520520	1.520516	−0.000004	0.0000003
e	0.02147670	0.02147675	0.00000005	0.000000002
a, (AU)	1.012305100	1.012305106	0.000000006	0.0000000023

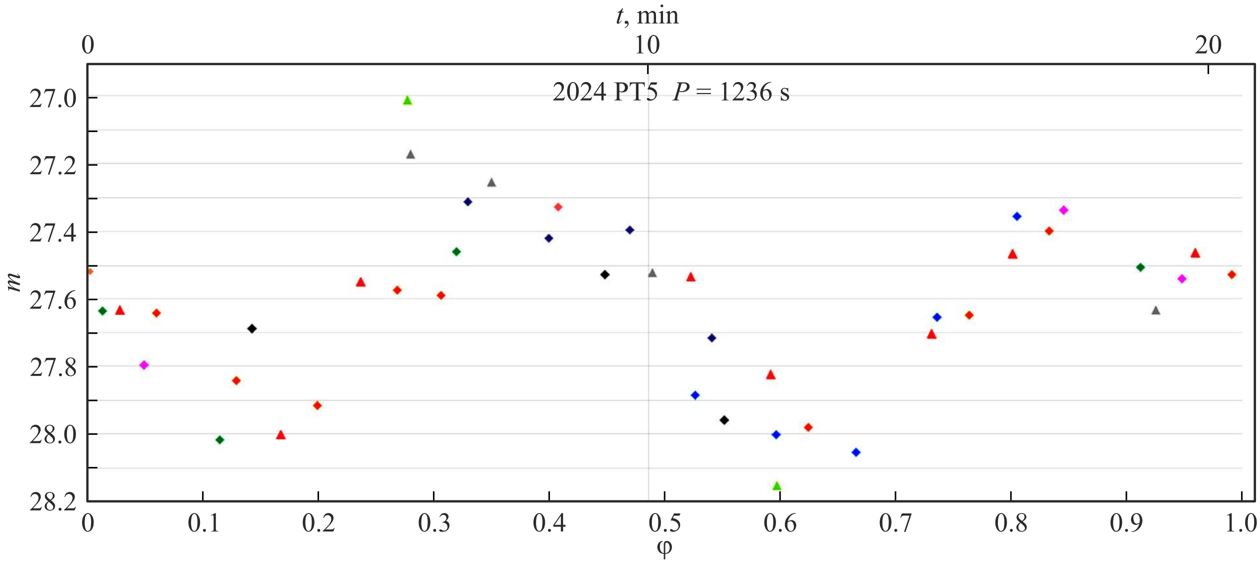

Figure 2. The light curve of asteroid 2024 PT5, collected with a period of 1236 s (20.6 min). The upper abscissa axis represents time t [min], the lower axis represents the asteroid's rotation phase φ (dimensionless), and the ordinate axis represents the magnitude m in stellar magnitudes. The symbols that make up the light curve, which are different in color and shape, correspond to different observation dates.

interpretation were carried out using the EPOS software package [6]. Based on the totality of our observations conducted from December 25, 2024, to January 28, 2025, and observations taken from the Minor Planet Center (MPC) database, the orbital elements of the asteroid 2024 PT5 were clarified. The results of the orbit improvement with an estimate of the accuracy of the values obtained are shown in Table 2, where M is the mean anomaly, ω is the argument of the periapsis, Ω is the longitude of the ascending node, i is the inclination, e is the eccentricity, a is the semi-major axis. The initial estimate of the coincidence of observations and orbit (RMS, residuals) was $2''.491$, while after the orbit improvement it was $0''.542$.

Frequency analysis to search for periods in the series of observations was performed using the Scargle method [7]. Using 45 of the most reliable measurements of the brightness of the asteroid 2024 PT5, distributed over 37 days, we estimated the period of its axial rotation. The Scargle periodogram, based on this series, allowed us to obtain the following value for the period of axial rotation of the asteroid 2024 PT5: $P = (1236 \pm 18)$ s (Fig. 2). The result obtained is in good agreement with the estimate published in Ref. [1], where, based on the results of observations of the asteroid 2024 PT5 on the 10.4-m GTC telescope (Gran Telescopio CANARIAS), an axial rotation period equal to $P = (1260 \pm 120)$ s (based on one hour of observations) was obtained.

The evolution of the orbital elements was studied using the EPOS software package [6]. Fig. 3 shows, for example, the evolution of the semi-major axis and orbital eccentricity of the asteroid 2024 PT5 at the time of its close approach in 2024 and the upcoming approach in 2055, as well as some time before and after these approaches.

Non-gravitational effects were estimated for the asteroid 2024 PT5: the pressure of solar radiation and the Yarkovsky effect, which is a weak reactive impulse due to anisotropic thermal radiation from the surface of a rotating asteroid. The maximum displacement of the asteroid under the influence of radiation pressure before the upcoming approach (in 31 years) will be about $9.6 \cdot 10^5$ m. The calculation method is described in Ref. [8], calculations were performed with the initial data from MPC [9]. The

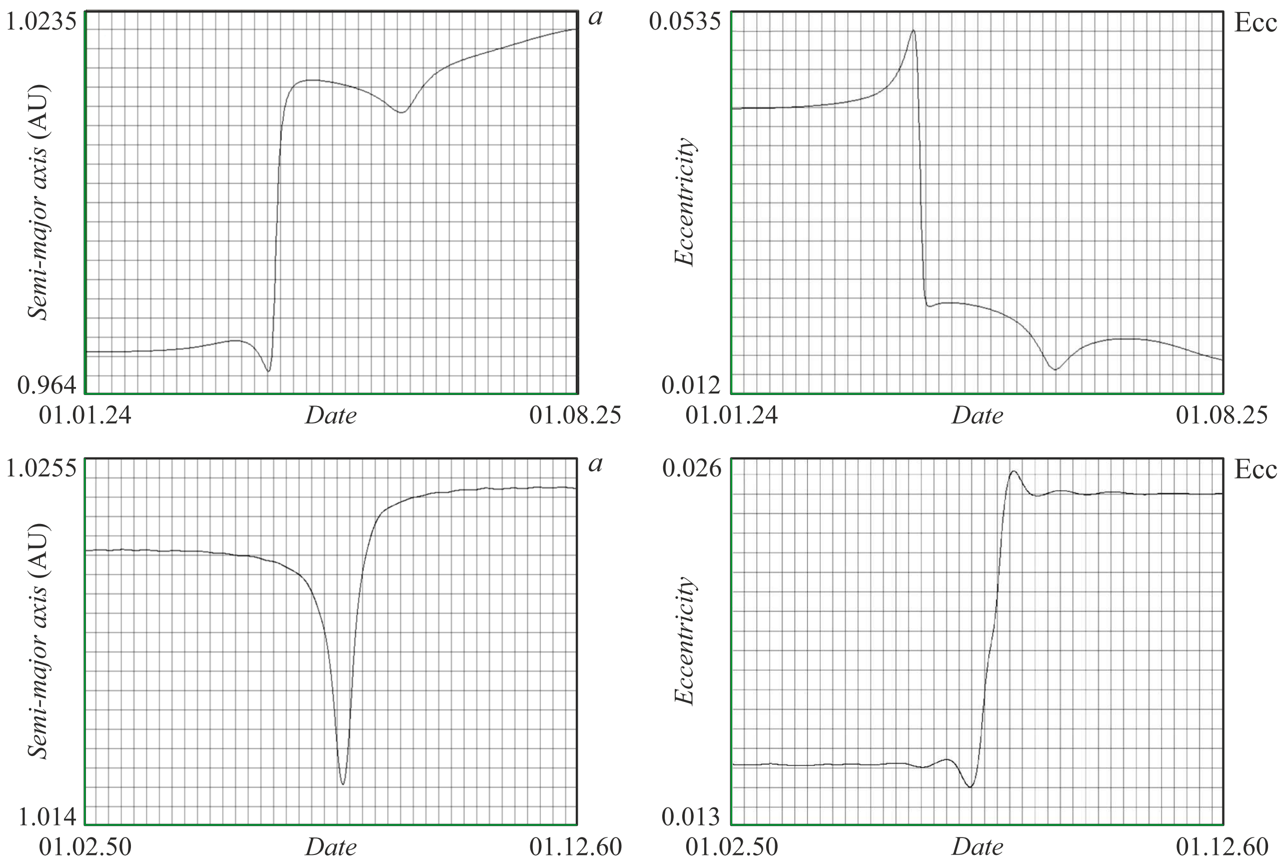

Figure 3. Evolution of the semi-major axis and the orbital eccentricity of the asteroid 2024 PT5. in the time interval 01.01.2024–01.08.2025 and 01.02.2050–01.12.2060.

Table 3. The magnitude of the Yarkovsky effect per asteroid revolution around the Sun, depending on the angle of inclination axis rotation

0°	45°	90°	135°	180°
$8.5082 \cdot 10^{-11}$ AU (0.0127 km)	$5.9508 \cdot 10^{-11}$ AU (0.0089 km)	$-1.3085 \cdot 10^{-12}$ AU (−0.0002 km)	$-6.0817 \cdot 10^{-11}$ AU (−0.0091 km)	$-8.5082 \cdot 10^{-11}$ AU (−0.0127 km)

density was assumed to be average, 3000 kg/m^3. The albedo of the asteroid δ, equal to 0.18, was calculated using the formula $\lg\delta = (3.122 - \lg D - 0.2H)/0.5$ [10], where H is the absolute magnitude of 27.45, D is the diameter of the asteroid. Table 3 shows the values of the Yarkovsky effect for various possible values of the angle of inclination of the asteroid's rotation axis, since its real value is unknown. The thermodynamic model of accounting for the Yarkovsky effect is taken from the Ref. [11–13].

Thus, for the asteroid 2024 PT5, a complex of astrometric and photometric studies was performed, the evolution of motion and the influence of non-gravitational effects were studied. In the coming decades, this asteroid does not pose a threat to the Earth.

Funding

The work was performed within the framework of the state assignment 075-03-2025-080, approved by the Ministry of Science and Higher Education of the Russian Federation (topic № 125021201995-7,„COSMOMETRY").

Conflict of interest

The authors declare that they have no conflict of interest.

References

[1] R. de la Fuente Marcos, J. de Leon, M. Serra-Ricart, C. de la Fuente Marcos, M.R. Alarcon, J. Licandro, S. Geier, A. Tejero, A. Perez Romero, F. Perez-Toledo, A. Cabrera-Lavers. A & A, **694**, (2024). DOI: 10.1051/0004-6361/202452713

[2] T. Kareta, O. Fuentes-Muñoz, N. Moskovitz, D. Farnocchia, B.N.L. Sharkey. ApJL, **979** (1), (2025). DOI: 10.3847/2041-8213/ad9ea8

[3] Electronic resource. Available at: https://ssd.jpl.nasa.gov/tools/sbdb_lookup.html#/?sstr=2024PT5&view=OPC

[4] A.P. Kulish, A.V. Devyatkin, V.B. Rafalsky, F.M. Ibragimov, V.V. Kupriyanov, I.A. Vereshchagina, A.V. Schumacher. Izv. GAO, **219** (1), 192 (2009) (in Russian).
[5] A.V. Devyatkin, D.L. Gorshanov, V.V. Kouprianov, I.A. Verestchagina. Sol. Syst. Res., **44** (1), 68 (2010). DOI: 10.1134/S0038094610010090
[6] V.N. L'vov, S.D. Tsekmeister. Sol. Syst. Res., **46** (2), 177 (2012). DOI: 10.1134/S0038094612020074
[7] J.D. Scargle. ApJ, **263**, 835 (1982). DOI: 10.1086/160554
[8] A.A. Martyusheva, N.A. Petrov, E.N. Polyakhova. Vestn. SPbSU, **2** (60), 135 (2015) (in Russian).
[9] Electronic resource. Available at: https://www.minorplanetcenter.net/db_search/show_object?utf8=%E2%9C%93&object_id=2024+PT
[10] T.A. Vinogradova, N.B. Zheleznov, V.B. Kuznetsov, Yu.A. Chernetenko, V.A. Shor. Tr. IPA RAN, **9**, 43 (2003) (in Russian).
[11] D. Vokrouhlický. Astron. Astrophys., **344**, 362 (1999).
[12] D. Vokhrouhlický, A. Milani, S.R. Chesley. Icarus, **148** (1), 118 (2000). DOI: 10.1006/icar.2000.6469
[13] A.I. Panasenko, Yu.A. Chernetenko. Tr. IPA RAN, **31**, 59 (2014) (in Russian).

Translated by A.Akhtyamov