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Asteroid 2408 upon the 100th birthday of Igor Stanislavovich Astapovich

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Abstract. 2008 was the year of the 100th birthday of Igor Stanislavovich Astapovich, who was a pioneer of meteor astronomy in the former USSR. The main-belt asteroid 2408 was named after him in 1983, in recognition of his well-known research. The orbital evolution of the asteroid Astapovich over an interval of 210 400 years is presented. The asteroid's longitude of perihelion moves 1.8° per 100 years. From photometric observations of the asteroid, obtained at the Skalnaté Pleso Observatory in July 2008, its synodic rotational period of 3.68 h was determined.

Key words: I.S. Astapovich – asteroid 2408 – photometry of asteroids – orbital evolution

1. Igor Stanislavovich Astapovich

Igor Stanislavovich Astapovich was born on January 11, 1908 in the town of Volchansk, Kharkov region. This was the year of great importance for meteor astronomy, the year of a unique event known as the Tunguska phenomenon. On June 30, 1908 a small cosmic body collided with the Earth.

Astapovich's father was taught physics and mathematics and his mother had a diploma of house teacher. The large family's library included, besides many other books, also books of C. Flamarion, F. Argo, F. A. Bredikhin, and K. D. Pokrovskii. This intellectual background to where Astapovich was born formed his interest and character from early childhood.

During 1924–1926 Astapovich studied at the school of Nikolaev, where he obtained joinery and mechanical workshop practice before rising to a rank of engineer. A dominant role for his astronomy carrier was played by the Russian Amateur Society for Nature. This Society was established again in 1908.

The first publication of meteor observations by Astapovich dates back to 1923. On August 20 1925, he and S. S. Trikotskii observed a fireball of -12^{m} and recorded the drift of the trail over 18 min. Its estimated velocity was 74 $\mathrm{km\,s^{-1}}$. The observer was a 17-year old graduated pupil.

Figure 1. Igor Stanislavovich Astapovich (1908–1976).

In 1926 Astapovich enrolled in the Faculty of Physics and Mathematics of Moscow University. Following his family, he moved to Leningrad University in 1928. In this year Astapovich published a booklet on *The task of the amateurs in meteor astronomy*.

Astapovich finished his studies at the University in 1930 by earning a degree in astronomy. In 1930–1931 he became a PhD. student at the Pulkovo Observatory. In 1932 he took part in expeditions to Eastern Siberia and discovered a deposit of magnetite.

Astapovich's great attention to the study of archives of observations of the Tunguska phenomenon led to his idea about a cometary origin for this event. It was the first such assumption in the world science.

In 1933 Astapovich was appointed the director of the newly build Stalinabad Astronomical Observatory, where he started spectroscopic observations of meteors. After serious malaria illness, in 1934 he came to work as a senior researcher to the Sternberg State Astronomical Institute of Moscow University. In the following year he received a degree of a candidate of phys.-math. sciences (PhD.) and was elected a member of the Commission 22 of the International Astronomical Union. He organized the first All-Union conferences on comets and meteor investigations in 1935, 1937, and 1939.

In 1958 he published the book on *Meteor Phenomena in the Earth's Atmosphere*, which became the *Meteor Almagest*. It remains one of the most cited works in this field of science. At the beginning of the Second World War Astapovich became a soldier in the Artillery Regiment of the 8th Krasnopresnensk Division of the 32nd Army. After demobilization in 1941 he was sent to Ashkhabad. The complete archive of his observations contains data on more than 40 000 meteors.

From July 1, 1942 Astapovich began systematic observations of the Gegenschein in Turkmenistan, with excellent observing conditions. His sister, V. S. Astapovich made simultaneous observations in Karelia. From sample of 214 observations he found the intensity variation of the Gegenschein and the coincidence with the appearance of a powerful aurora.

During a period 1959–1961 Astapovich worked in Odessa. In 1963 Astapovich successfully defended his doctoral dissertation (DrSc.). Jointly with A. K. Terent'eva (his wife), E. I. Kazimirchak-Polonskaya, and N. A. Belyaev, he solved a celestial mechanics problem of the motion of the Leonid meteoroid stream.

Astapovich spent the last period of his life in Kiev, having a chair at Kiev University. He passed away on January 2, 1976 but ideas of his work remain alive. His work was and still is full of inspiration for his and next generations of meteor astronomers.

For more information about I. S. Astapovich's life see e. g. Romeyko (2009), Smirnov (1999), Terentjeva (2001), Terentjeva, Churyumov (2008).

2. Asteroid 2408 Astapovich

The asteroid was discovered by Nikolay S. Chernich on August 31, 1978 at Nauchnyj, Krimean Observatory. The asteroid belongs to the main asteroid belt. Its orbital elements for the Epoch 2008 November 30.0 and the Equinox 2000.0 are: $e = 0.2443897$, $a = 2.6356504\,\mathrm{AU}$, $q = 1.9915246\,\mathrm{AU}$, $Q = 3.2797762\,\mathrm{AU}$, $i = 17.69525°$, $\Omega = 164.49347°$, $\omega = 103.07431°$, $M = 73.66784°$, $T = 2008$ Jan. 15.18003 UT, $P = 1562.8962186$ day $= 4.28$ year, $n = 0.23034159°\,\mathrm{day}^{-1}$. The orbit was determined from 375 observations from the interval of 1943 to 2006 11 21 (Yeomans, 2009). Physical parameters of the asteroid are: absolute magnitude $+12.50^{\mathrm{m}}$, diameter 20.83 km, and albedo 0.0407, which is the albedo of fresh asphalt.

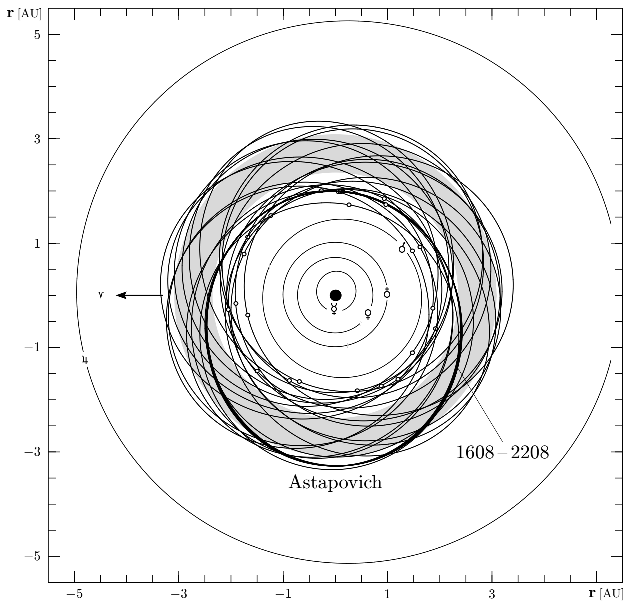

Figure 2. The orbital evolution of the asteroid Astapovich between January 11, 1600 and January 1, 212 000. An interval between every two consecutive osculating orbits since January 1, 2000 to January 1, 212 000 is 10 000 years. The smaller interval, 1000 years, is between the osculating orbits within the interval from January 11, 1608 to January 11, 2208. The gray area represents the main belt of asteroids. The dots on the orbits denote the position of the perihelion in each osculating orbits.

The asteroid was named Astapovich by the International Astronomical Union on March 28, 1983 in recognition of Astapovich's well-known research activities.

3. Orbital evolution of asteroid Astapovich

The asteroid's orbit is quite stable with only small perturbations mainly from Mars and Jupiter. The changes of orbital elements within the interval from 2000 to 212 000 are following: The inclination i varies between 12.6° and 17.8°, the eccentricity e between values of 0.21 and 0.33, and the perihelion distance q between 1.17 AU and 2.10 AU. The longitude of perihelion ω moves 1.8° per 100 years.

In Figure 2 we can see the orbital evolution of the asteroid within the interval from 1608 to 212 000. The osculating orbits are plotted every 10 000 years, and within the interval from 1600 to 2200 every 1000 years.

4. Photometry of asteroid Astapovich

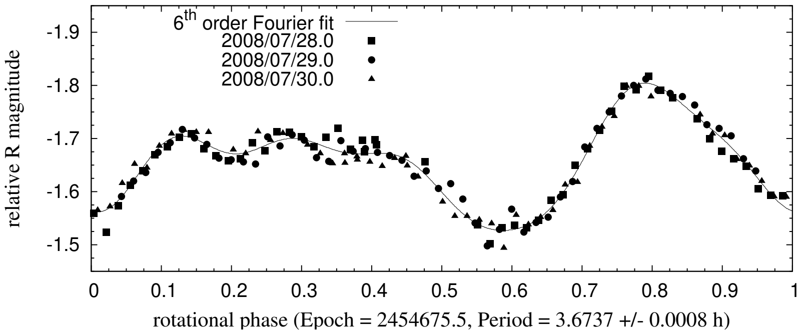

Figure 3. The composite lightcurve of asteroid Astapovich between July 28–30, 2008.

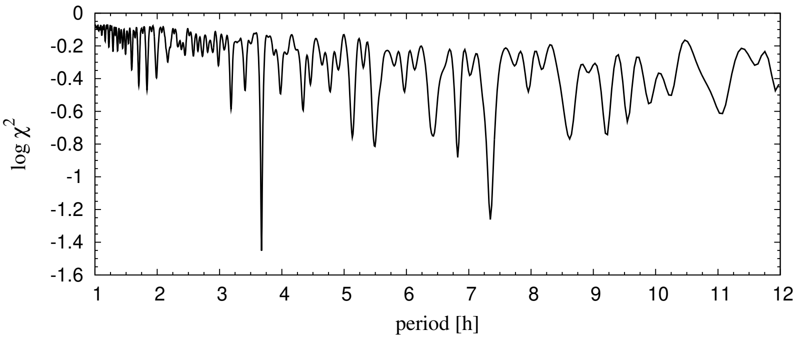

Figure 4. A plot of the sum of square residuals vs. period for (2408) Astapovich.

Table 1. The aspect data for asteroid 2408 Astapovich observed at the Skalnaté Pleso Observatory.

Date 2008 UT	r AU	Δ AU	α $^\circ$	R.A. h m	Decl. $^\circ$ $'$	L_{PAB} $^\circ$	B_{PAB} $^\circ$
07 28.0	2.281	1.519	20.8	23 46	+02 23	347.6	+2.9
07 29.0	2.283	1.512	20.5	23 46	+02 16	347.7	+2.9
07 30.0	2.286	1.505	20.2	23 47	+02 09	347.8	+2.8

Table 2. Coordinates and magnitudes of the comparison stars used for differential photometry.

Date 2008 UT	USNO-A2.0 0900-	R.A.$_{2000.0}$ h m s	Decl.$_{2000.0}$ $^{\circ}$ $'$ $''$	B mag	R mag
07 28.0	20491706	23 47 16.81	+02 25 25.9	15.7	14.7
07 29.0	20489376	23 46 41.73	+02 16 59.4	15.0	13.7
07 30.0	20489254	23 46 39.72	+02 09 16.3	14.9	13.9

Photometric observations were obtained with a 0.61-m Newtonian reflector at the Skalnaté Pleso Observatory, using a CCD camera SBIG ST-10XME in its 2.62-m focus. The asteroid was observed during three consecutive nights, from July 28 to July 30, 2008. Total observational time was 11 hours. The predicted V brightness of the asteroid was $+16.5^{\mathrm{m}}$. We used the Johnson-Cousins R photometric filter and typical exposure times at 180 seconds in each night.

The synodic rotational period 3.6737 ± 0.0008 h was determined by the method of the differential aperture photometry (selected comparison stars are in Table 2). The composite lightcurve (Fig. 3) with 159 points was fitted by a single-period 6-th order Fourier fit (Fig. 4). With respect to the favourable viewing/illumination geometric conditions of the asteroid towards to the Sun and the Earth, the lightcurve amplitude reached up 0.28^{m}. Therefore the determined rotational period is adequately reliable.

In Table 1 r and Δ are the heliocentric and geocentric distances, α is the phase angle, R.A. and Decl. are the asteroid's J2000.0 geocentric right ascension and declination, and L_{PAB} and B_{PAB} are the J2000.0 ecliptic coordinates of the phase angle bisector (PAB is the vector connecting the center of the asteroid and the midpoint of the great circle arc between the sub-Earth and sub-solar points).

5. Conclusion

The asteroid 2408 Astapovich belongs to main belt asteroids and its orbit is quite stable. Its perihelion moves 1.8° per 100 years. Within the interval from 1600 to 212 000 its inclination varies between 12.6° and 17.8°, eccentricity between values of 0.21 and 0.33, and perihelion distance between 1.17 AU and 2.10 AU. The synodic rotational period of the asteroid is 3.6737 ± 0.0008 h. The value was determined from 159 photometric points obtained from July 28 to July 30, 2008.

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