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Astrometric observations of asteroids and comets at the Molėtai Astronomical Observatory

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Abstract. We describe the observational project devoted to astrometric observations of Near-Earth Objects (NEO), main belt asteroids and comets at the Molėtai Observatory, Lithuania. Exposures are obtained with the two telescopes of the observatory: 0.35/0.50 m f/3.5 Maksutov telescope and the 1.65 m f/3.1 reflector with a CCD camera. The results of more than 8 800 positions of asteroids and comets have been published in the Minor Planet Circulars and Minor Planet Electronic Circulars. During the 2001–2005 period 121 new main belt asteroids were discovered and a few NEO objects were detected independently.

Key words: Minor planets, comets

1 Observations of minor planets

Our project serves as a study of asteroids and comets for a better prediction of their orbits and thus their Earth-impact threat. First astrometric observations of comets at the Molėtai Astronomical Observatory (longitude 25.57 E, latitude 55.32 N, altitude 210 m) have been started in 1998 using a 0.41 m f/6 Schmidt-Cassegrain telescope with a small Meade CCD camera (Černis and Janulis 1998). In a period of 2000–2001 the Tromso (Norway) CCD photometer TK1024 with two-stage thermoelectric cooling was used with the 0.35 m Maksutov Newtonian reflector for astrometric observations of asteroids and comets (Černis and Laugalys 2000, 2001).

The Maksutov telescope with Tromso CCD produced a scale of 4.1"/pixel. First three new asteroids have been discovered in 2001: 2001 OM65, 2001 UM14 and 2001 UU175. The first asteroid, deep Mars crosser 2001 OM65 have been discovered with the 1.65 m telescope with focal reducer f/8. Other two asteroids were discovered with the Maksutov reflector.

Systematic astrometric observations of asteroids and comets began in 2002 when a new VersArray CCD camera (with liquid nitrogen cooling) has been purchased by the Institute of Theoretical Physics and Astronomy. With this camera the Maksutov telescope produces a scale of 3.4"/pixel (Zdanavičius 2003). The 1.65 m reflector with a new focal reducer gives much better astrometric precision, having a scale of 0.9"/pixel. All measurements were done using the Astrometrica software (Raab 2003). The catalogues USNO-A2.0, USNO-B1.0 and UCAC-2 were used for selection of the reference stars. Limiting magnitude for stars with the Maksutov telescope is about 20.5 R magnitude on unfiltered images with the exposure time about 360 s (field-of-view 76'×80'). It is a very useful instrument to follow-up astrometry of poorly observed bright NEOs, unusual objects and comets. About 2300 high-quality CCD images were obtained for astrometric work of asteroids and comets during the four last years.

During sky survey in near ecliptic regions in 2002–2005 and during NEO asteroid follow-up astrometry 110 new asteroids have been discovered. Our site (IAU Code 152) in total has discovered 113 objects, 46 of the discoveries are involved in multiple-apparition, 41 of the discoveries are involved in one-opposition object orbits, 22 objects of the one opposition objects have calculated orbits with low accuracy. For 103 objects the orbit have been determined.

Eight additional minor planets have been discovered by one of the authors (K. Černis) using the NEAT CCD frames obtained at the Palomar Mountain Observatory (IAU Code 644) with 1.24 m Oschin Schmidt telescope in 2003 (Helin et al. 2003, 2004).

Among the discovered asteroids there are a few unusual objects: Hilda group asteroid 2004 TB21 with $a = 3.98$ AU, 2005 TW52 with $e = 0.4$, Mars crossers 2001 OM65 and 2005 TB50. During the investigation of our CCD frames three NEO asteroids and one unusual object have been discovered independently: Apollo-type object 2004 EP20 ($q = 0.58$ AU); Amor-type asteroids 2004 DK1 ($q = 1.1$ AU) and 2005 EL1 ($q = 1.3$ AU); one Hungarian-type object: 2005 SK1 ($a = 1.92$ AU).

Table 1 shows the number of our discoveries, number of astrometric observations, number of observed objects and references to published data in the IAU Minor Planet Circulars.

Таблица 1. Distribution of discoveries and numbers of astrometric observations of asteroids according to time.

Year	Number of discoveries	Number of observations	Number of observed objects	References (MPC No.)
2000	0	58	26	41639
2001	3	141	35	42977, 43111, 43450, 43833
2002	12	442	99	44289, 44718, 45048, 45452, 45855, 46218, 46511, 46858
2003	13	643	179	47507, 47996, 48621, 49430, 49886
2004	55	2233	503	50599, 51502, 52495, 52889
2005	36	5252	1230	53631, 54346, 54967, 55473
Total	119	8769	2072	

Table 2 shows the distribution of numbers of observed comets, astrometric observations of comets and references to the published data (IAU Minor Planet Circulars and Minor Planet Electronic Circulars).

The results of about 8 800 astrometric positions of more than 2 000 asteroids and 16 comets, including the NEO asteroids (2000 LL, 2000 PH5, 2001 KP41, 1990 SB, 2001 LF, 2000 GX 100, 2001 MZ7, 2001 MF1, 2001 KX67, 2002 EX11, 2004 EP20, 2005 SK1, 2005 RK7, 2005 TR, 2005 TP45, 2005 TG50, 2005 TD, 2005 TS45) and transneptunian objects (2002 UX25, 2003 UB313) have been already published in Minor Planet Circulars and MPEC circulars (Černis, Zdanavičius 2002, 2005; Černis, Zdanavičius, Zdanavičius 2004, 2005).

Almost all asteroids have absolute magnitudes in the range $H = 15$ – 18 mag. Asteroids 2002 FU10 with $H = 14.2$ mag and Amor-type object 2004 DK1 with $H = 21.2$ mag have the extremely values of H . Spatial distribution of absolute magnitudes H versus semiaxes a for 102 our discovered objects is shown in Fig. 1. The vertical axis of H is connected with a photometric diameter of the minor planet. We estimate that our objects are in diameter from 200 m to 7 km.

Fig. 2 shows the distribution of i (orbital plane inclination) and orbital parameters e (eccentricity) of

^ **Таблица 2.** Distribution of numbers of observed comets and numbers of astrometric observations of comets according to time.

Year	Number of observed comets	Number of observations	References (MPC and MPEC)
2000	7	48	MPC 42236, MPC 42959
2001	1	21	MPEC 2001-R57
2002	2	25	MPC 43426, MPEC 2002D-38, MPEC 2002G-38, MPEC 2002-G40
2005	6	52	MPC 54967, MPC 55473, MPEC 2005-U04, MPEC 2005-V88, MPEC 2005-V90, MPEC 2005-V91, MPEC 2005-V95
Total	16	146	

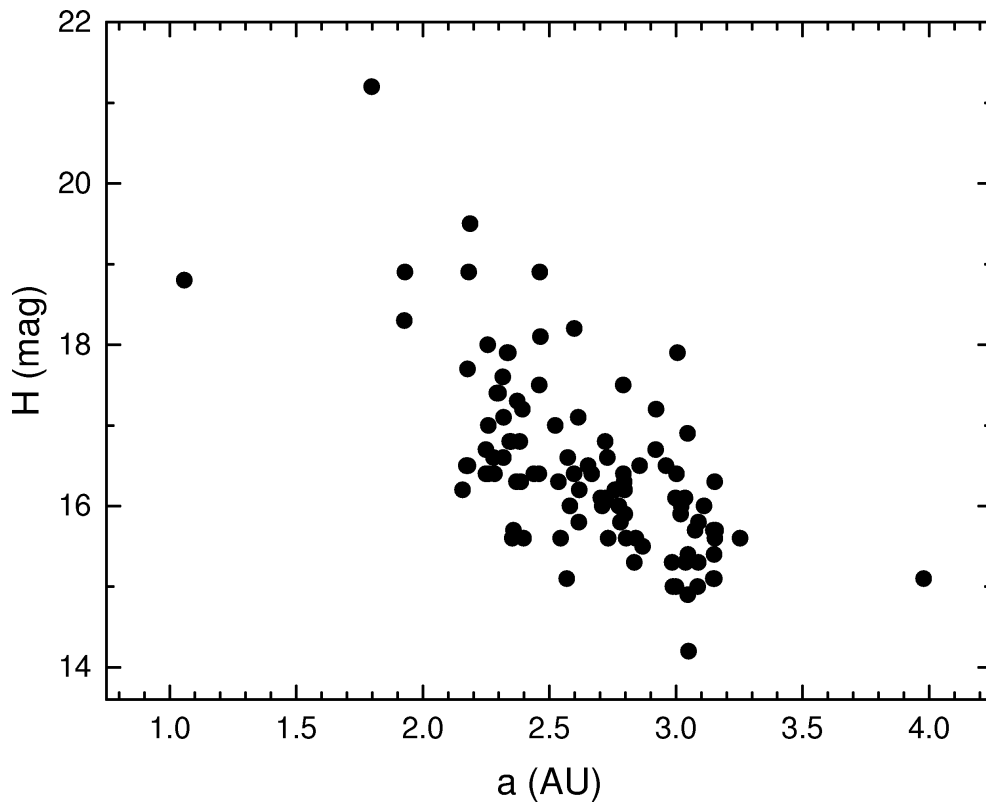


Fig. 1. Absolute magnitudes H of the discovered asteroids versus their semiaxes a .

the discovered asteroids . We can see that the most orbits have $e < 0.3$ and $i < 20$ deg. Extreme values of e (about 0.4) have four objects: all NEO asteroids (2004 DK1, 2004 EP20, 2005 EL1) and one main-belt asteroid 2005 TW52. The largest values of orbit inclination ($i = 25-28$ deg) have the NEO asteroid 2005 EL1, main-belt asteroids 2002 TP303, 2003 FB123 and two Hungarian-type asteroids.

The analysis of statistical properties of the discovered main-belt asteroids share the known characte-

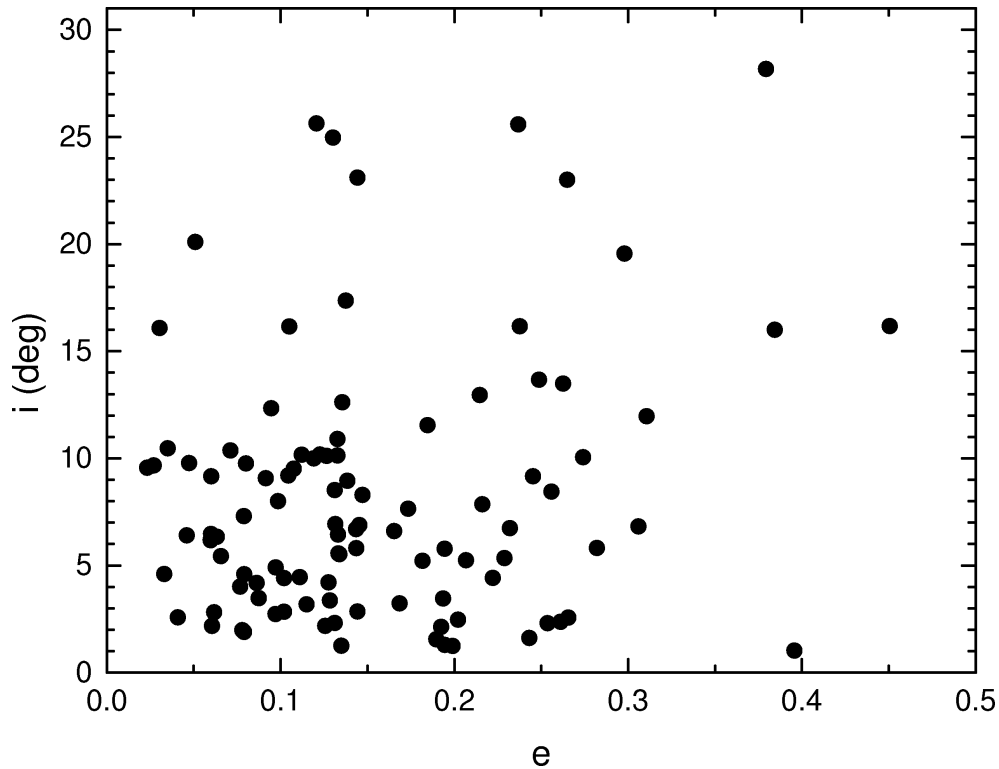


Fig. 2. Distributions of the asteroid orbit inclination (i) versus eccentricity (e)

istics of the main belt.

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