Detection and Identification of Asteroids with the 4-m ILMT

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Abstract

A very unique strength of the Devasthal Observatory is its capability of detecting optical transients with the 4-m International Liquid Mirror Telescope (ILMT) and to rapidly follow them up using the 1.3-m Devasthal Fast Optical Telescope (DFOT) and/or the 3.6-m Devasthal Optical Telescope (DOT), installed right next to it. In this context, we have inspected 20 fields observed during nine consecutive nights in October–November 2022 during the first commissioning phase of the ILMT. Each of these fields has an angular extent of $22'$ in declination by $9 \times 22'$ in right ascension. Combining both a visual search for optical transients and an automatic search for these using an image subtraction technique (see Pranshu et al., 2024), we report a total of 232 significant transient candidates. After consulting the Minor Planet Center database of asteroids, we could identify among these 219 positions of known asteroids brighter

than $V = 22$. These correspond to the confirmed positions of 78 distinct known asteroids. Analysis of the remaining CCD frames covering 19 more fields (out of 20) should lead to an impressive number of asteroids observed in only nine nights. The conclusion is that in order to detect and characterize new supernovae, micro-lensing events, highly variable stars, multiply imaged quasars, etc. among the ILMT optical transients, we shall first have to identify all known and new asteroids. Thanks to its large diameter and short focal length ($f/D \simeq 2.4$), the ILMT turns out to be an excellent asteroid hunter.

Keywords: ILMT, asteroids, survey, telescope

1. Introduction

First light has been obtained with the 4-m ILMT on 29th April 2022 (Surdej et al., 2022). The ILMT consists of a high precision photometric and astrometric survey instrument observing at the zenith in the Time Delay Integration (TDI) mode (see Surdej et al., 2024, for more details). The singly scanned CCD frames correspond to an integration time of 102 s, i.e., the time an object's image remains within the active area of the detector. A unique niche for the ILMT is the detection of optical transients for which rapid spectroscopic follow-up observations with the 3.6-m DOT or direct imaging with the 1.3-m DFOT or 3.6-m DOT telescopes can be easily carried out.

We were thus very much interested in searching for optical transients in the ILMT observations collected during nine nights in October–November 2022. They consist of 3 times 3 nights using the *g*, *r* and *i* Sloan spectral filters. Among these, only the *i*-band observations were obtained during three consecutive nights (28th–30th October 2022). Our first approach for detecting optical transients has been to start with a visual search of these frames for transients (see Fig. 1). These detections were then used to calibrate an automatic search for optical transients making use of the image subtraction technique. We then noticed that optical transients associated with many triplets showed similar angular separations and orientations. They naturally consisted of good asteroid candidates. This was confirmed after consulting the asteroid database of the Minor Planet Center. We then made use of the optical transients detected in the other spectral bands (*g* and *r*) to extend our search for asteroids and other transient candidates. We present here the observations and a detailed analysis of just one of the 20 fields imaged with the ILMT in October–November 2022.

2. Observations and Detailed Analysis

Each of the fields observed with the ILMT in October–November 2022 covers a rectangular solid angle of $22' \times 198'$ with its length aligned along the right ascension axis. They have been observed during three consecutive nights with the *i* filter (i.e., the nights of 28th, 29th and 30th October 2022). Defining an optical transient as being a source appearing clearly on only one of the three *i*-band frames and an asteroid candidate as consisting of three transients detected at the three different epochs, showing similar angular separations while being properly oriented as a function of time, a total of more than 173 asteroid candidates have been visually identified.

Figure 1: Excerpt of a RGB-like composite picture consisting of the superposition of three *i*-band CCD frames recorded with the ILMT on the nights of 28 (blue dot), 29 (yellow dot) and 30 (red dot) October 2022. Near the red dot, an additional blue one is visible corresponding to another optical transient detected on 28th October. Most of the stars which are present on the three frames appear white-like on this picture. Visual inspection of such frames easily leads to the identification of optical transients.

Furthermore, we report in these same fields ~ 600 additional *i*-band detections of transients which could be other known or new asteroids, highly variable stars, multiply imaged quasars, supernova candidates, etc. Concentrating on just one of those 20 fields, i.e., the field with its RA (2022.8) starting at 04 h 32 m, we have visually identified 22 known asteroids reported in the database of the Minor Planet Center. Making use of the automatic identification of transients based upon the image subtraction technique applied to the three *g*, *r* and *i*-band CCD frames covering this same field (see Pranshu et al., 2024), we could identify 53 additional known asteroids reported in the Minor Planet Center database. Furthermore, 48 additional transients have been identified on the basis of the *g*-, *r*- and *i*-band CCD frames covering this unique field. Figure 1 illustrates the optical identification of three positions of a same asteroid on the nights of 28 (blue colour), 29 (yellow colour) and 30 October 2022 (red colour).

3. Results and Conclusions

Concentrating on the $22' \times 198'$ field taken at the Local Sidereal Time (LST) 4 h 22 m, we report a total of 231 optical transient candidates. After consulting the Minor Planet Center database of asteroids, we have found that 214 of these optical transients correspond to the positions of 78 known asteroids brighter than $V = 22$ mag. Among these, we find that 1 (resp. 2, 2, 3, 7, 11, 5, 21, 26) asteroids have been detected on 9 (resp. 8, 7, 6, 5, 4, 3, 2, 1) nights (see Table 1 and Figs. 2 and 3).

Analysis of the remaining CCD frames covering 19 more fields (out of 20) should lead to an impressive number of asteroids observed in just nine nights. The ILMT turns out to be an excellent asteroid hunter.

Table 1: List of the 78 asteroids detected with the ILMT during nine consecutive nights in October–November 2022. The symbol # indicates their label displayed in Fig. 2. The last column indicates the number of nights they were observed.

#	Asteroid	Nights	#	Asteroid	Nights	#	Asteroid	Nights
1	287600	1	27	285615	5	53	251579	2
2	398791	2	28	351463	8	54	290252	2
3	583720	1	29	449883	5	55	568319	2
4	72368	2	30	475809	4	56	66305	2
5	7377	2	31	2011 EK46	8	57	2005 UB252	1
6	121771	2	32	585743	2	58	2016 EL276	1
7	2009 UD159	1	33	243494	9	59	290365	4
8	528498	2	34	488998	3	60	599255	1
9	574664	1	35	54958	2	61	2013 HS101	1
10	271811	1	36	59790	7	62	349593	1
11	2022 SX245	1	37	232625	4	63	356264	6
12	38733	4	38	2005 UY125	1	64	65781	2
13	147247	7	39	350968	2	65	351688	2
14	2011 WM162	4	40	140914	1	66	101033	4
15	25526	5	41	2022 UQ89	2	67	224216	4
16	2017 QL25	2	42	270512	1	68	222288	5
17	87719	4	43	39161	3	69	166170	4
18	595633	6	44	354803	1	70	89412	4
19	261417	3	45	91818	5	71	402103	1
20	273964	5	46	594949	1	72	398828	5
21	423552	2	47	98222	4	73	2022 UM108	1
22	130440	2	48	568302	1	74	2001 YP31	3
23	149624	2	49	2005 UF171	1	75	125328	3
24	2014 EJ64	1	50	2009 UC166	1	76	250774	2
25	2019 NX78	1	51	304478	2	77	363975	1
26	37765	6	52	169617	1	78	568211	1
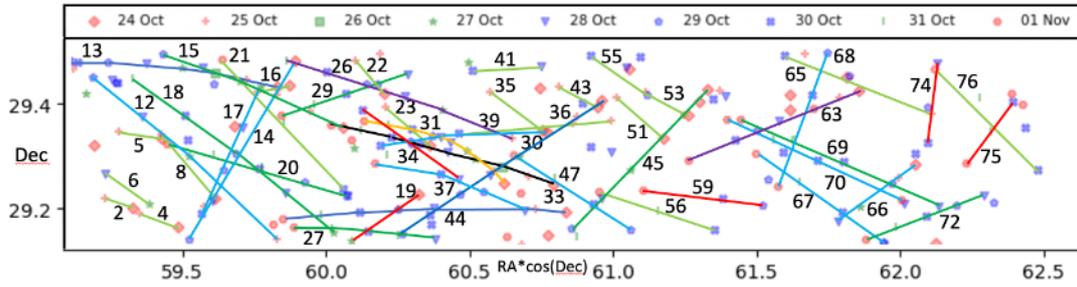
Figure 2: Paths of the 78 asteroids detected with the ILMT in the 04 h 32 m LST field during nine consecutive nights in October–November 2022. The horizontal and vertical axes represent the RA cos(Dec) and Dec in degrees, resp., where RA is the right ascension and Dec the declination of the asteroids for the 2000 epoch. The numbers refer to the asteroids listed in Table 1. The different coloured symbols correspond to the asteroid positions observed during the different nights.
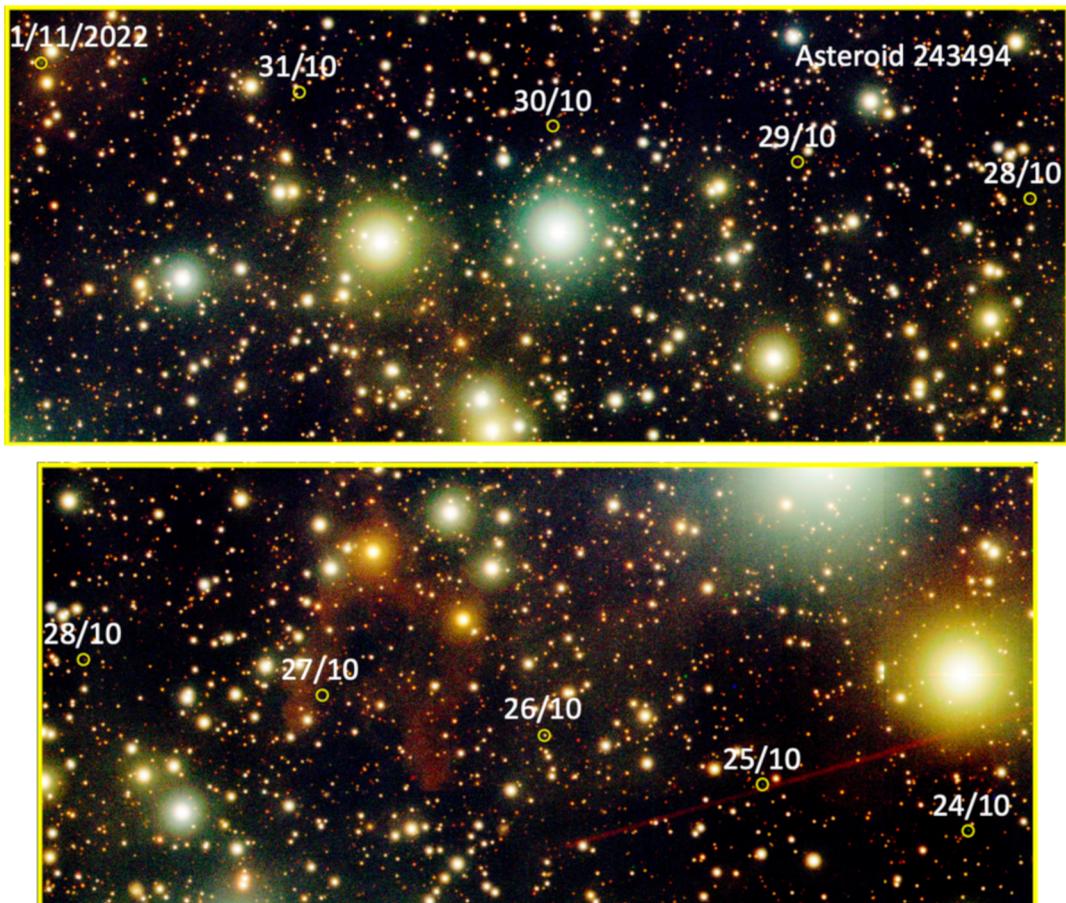
Figure 3: Example of an asteroid (243494) observed with the ILMT on nine consecutive nights in October/November 2022 using the *g*, *r* and *i* Sloan filters. The broad red streak is the signature of a passing space debris.

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Further Information

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Author contributions

This work results from a long-term collaboration to which all authors have made significant contributions.

Conflicts of interest

The authors declare no conflict of interest.

References

Pranshu, K., Ailawadhi, B., Akhunov, T., Borra, E., Dubey, M., Dukiya, N., Fu, J., Grewal, B., Hickson, P., Kumar, B., Misra, K., Negi, V., Sun, E. and Surdej, J. (2024) Automated transient detection in the context of the 4 m ILMT. BSRSL, 93(2), 828–836. https://doi.org/10.25518/0037-9565.11895.

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Surdej, J., Hickson, P., Kumar, B. and Misra, K. (2022) First light with the 4–m International Liquid Mirror Telescope. Physics News, 52, 25–28.