



The T025 - BD4SB

~a pro-am collaboration for planetary sciences~

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Introduction

- High performance astronomy equipment are now available at affordable prices for students and amateur astronomers
- Professional – amateurs (pro-am) collaborations are now common for transient events (which require rapid response) and for long term monitoring of bright celestial objects (e.g. Knapen 2011, Mousis et al. 2013, Gherase et al. 2015).

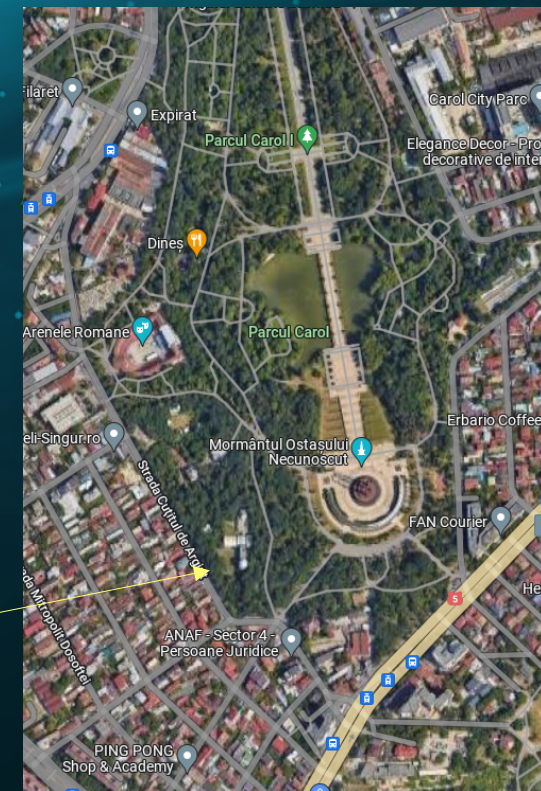
Aims

→ Contribute to scientific studies by systematically observing various celestial objects and phenomena

→ Attract students for a career in science and technology (in particular, for astronomy)

→ Learning facility for bachelor or master projects

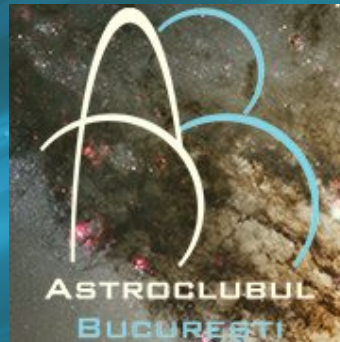
→ Public outreach during specific events



Our instrument is located at Astronomical Institute, on the upper terrace, near the historical dome. The location is inside Carol Park in area with a lot of trees and some houses.

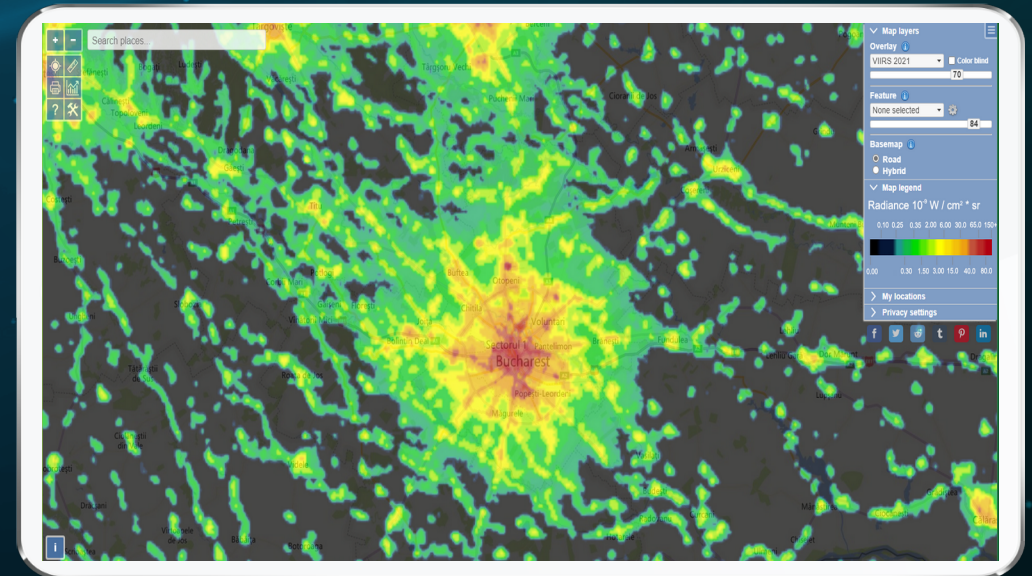
The environment

Excellent meeting place!



- Median limiting magnitude (detection at 2σ signal to noise ratio) ~ 20 in V band. The range is 19 (worst cases) - 20.7 (best cases)
- Median seeing: ~ 2.7 arcsec
- The sky brightness varies between seasons

Unfortunately, we are under light polluted sky....



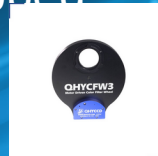
The setup

→ Lacerta 250/1000 Newtonian telescope mounted on Sky Watcher EQ6 Pro Go-To equatorial mount

→ QHY 294M Cooled CMOS Camera



→ Filter wheel: QHYCFW3, equipped with u,g,r,i Sloan filters



→ Diffraction grating: Star Analyser 100



- Alpy 600 spectrograph



- Mini-PC Beelink



→ Field of view: 66.1 x 44.4 arcmin²

→ Pixel scale: 0.952 arcsec/pixel



Image example of unvignetted field of view

→ Unvignetted field of view is ~ 40 x 30 arcmin²

The T025 - BD4SB Big Data for Small Bodies telescope

The software used

→ The setup is **fully robotized and it can be controlled remotely**. We use Nighttime Imaging 'N' Astronomy software (NINA)

<https://nighttime-imaging.eu/>

A big thank you to the developer!



Data reduction

→ Standard softwares: Astrometrica, Tycho, MPO Canopus, HOPS (HOlomon Photometric Software), and Astro Image J

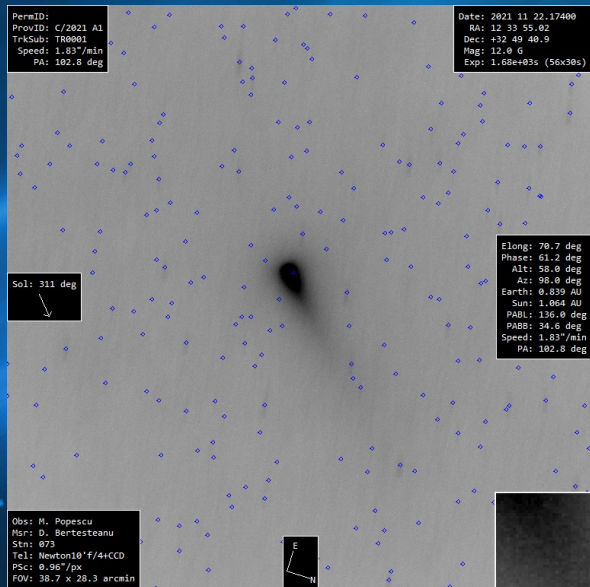
→ Image Reduction and Analysis Facility (IRAF) and AstrOmatic software suite (SourceExtractor, SCAMP, Swarp)

→ **Playground for developing our own pipelines** using Python (Astropy and PyRAF packages), GNU Octave, and GNU Astronomy Utilities (Gnuastro)



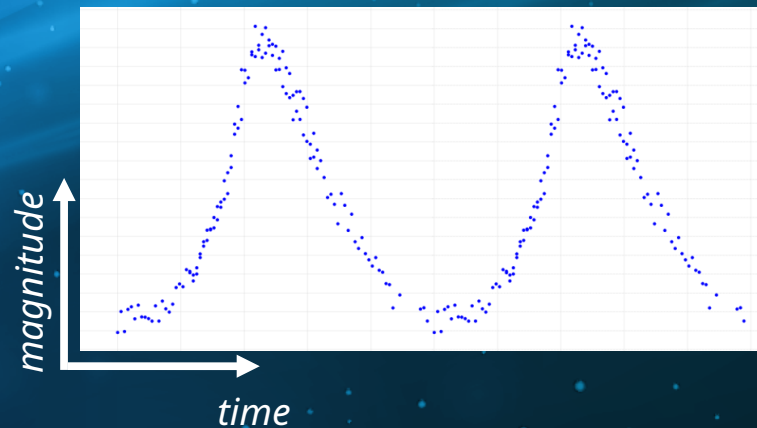
Ongoing observational projects

- High precision astrometry: astrometric observations of asteroids and comets, prioritizing the newly discovered near-Earth asteroids or those with uncertain orbits;
- Photometric observations of Solar System bodies with the aim to obtain accurate light-curves for deriving the spin-properties and their shape;
- Follow-up of various exoplanets transits;
- Occultations of trans-neptunian objects , participation in various international campaigns;
- Lightcurves of variable stars;
- Spectrophotometry and spectroscopy of bright sources;

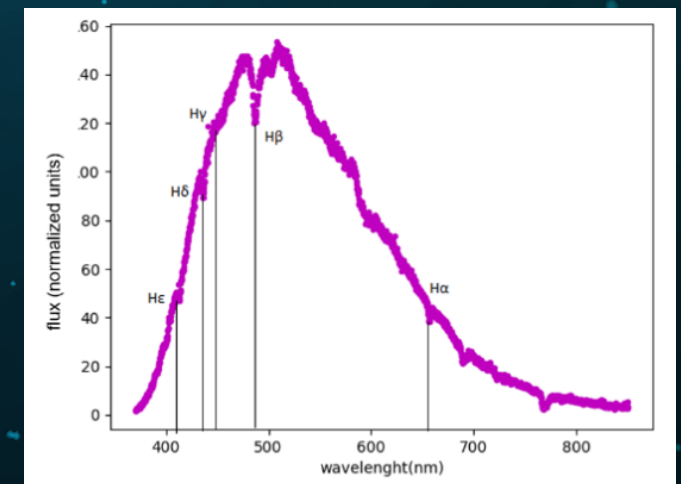
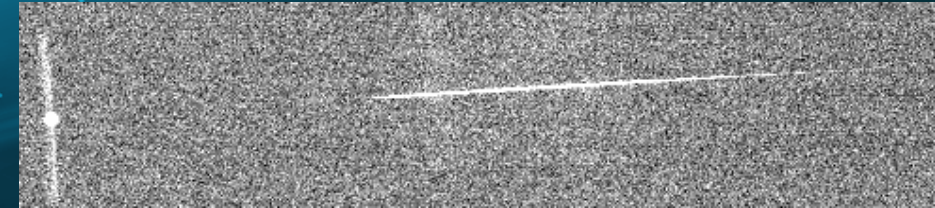


Astrometry

(image generated by Tycho software)



Photometry



Spectroscopy

Results: astrometry

~of small bodies from the Solar System (asteroids and comets) ~

→ We reported more than 100 observations to the Minor Planet Center (MPC). MPC observatory code 073 (inherited historically), focusing mostly on near-Earth asteroids

→ Typical O-C (observed minus computed/predicted positions) are smaller than 0.5 arcsec

→ The faintest asteroids we reported are of ~ 19.5 apparent magnitude

→ We participated to International Asteroid Warning Network Timing Campaign: 2019 XS, Farnocchia et al. 2022, The Planetary Science Journal

→ We obtained three Minor Planet Electronic circulars (confirmations of near-Earth asteroids discovery)

M.P.E.C. 2021-U91 Issued 2021 October 25, 23:28 UT

The Minor Planet Electronic Circulars contain information on unusual minor planets and routine data on comets. They are published on behalf of Division F of the International Astronomical Union by the Minor Planet Center, Smithsonian Astrophysical Observatory, Cambridge, MA 02138, U.S.A.

Prepared using the Tamkin Foundation Computer Network

MPC@CFA.HARVARD.EDU
URL <https://www.minorplanetcenter.net/> ISSN 1523-6714

2021 UV

Observations:

K21U00V*	C2021	10	25.33447302	16	02.97	+07	12	48.9	18.85GVEU091703	
K21U00V	C2021	10	25.33975502	16	02.95	+07	14	24.9	18.91GVEU091703	
K21U00V	C2021	10	25.34504102	16	03.02	+07	16	02.7	18.56GVEU091703	
K21U00V	C2021	10	25.35127702	16	03.02	+07	17	58.0	18.74GVEU091703	
K21U00V	C2021	10	25.44912302	16	05.36	+07	49	09.1	18.44GVEU091703	
K21U00V	C2021	10	25.44959302	16	05.35	+07	49	18.7	18.48GVEU091703	
K21U00V	C2021	10	25.45006302	16	05.39	+07	49	27.2	18.59GVEU091703	
K21U00V	KC2021	10	25.77069	02	17	29.16	+09	49	03.6	18.7 GXEU091G02
K21U00V	KC2021	10	25.77244802	17	28.22	+09	49	57.2	18.6 GVEU091L18	
K21U00V	KC2021	10	25.77569002	17	28.64	+09	51	23.6	18.6 GVEU091L18	
K21U00V	KC2021	10	25.77674	02	17	29.96	+09	51	42.5	18.6 GXEU091G02
K21U00V	KC2021	10	25.77893102	17	28.97	+09	52	47.7	18.7 GVEU091L18	
K21U00V	KC2021	10	25.78279	02	17	30.76	+09	54	21.1	18.9 GXEU091G02
K21U00V	KC2021	10	25.80666	02	17	33.41	+10	05	27.3	18.3 GVEU091073
K21U00V	KC2021	10	25.81410	02	17	34.09	+10	08	47.8	18.3 GVEU091073
K21U00V	KC2021	10	25.82151	02	17	34.73	+10	12	07.9	18.6 GVEU091073
K21U00V	KC2021	10	25.83418902	17	40.41	+10	16	59.9	18.2 VqEU091J69	
K21U00V	KC2021	10	25.83824302	17	40.94	+10	18	51.1	18.4 VqEU091J69	
K21U00V	KC2021	10	25.83984102	17	40.85	+10	20	12.5	18.1 GVEU091203	
K21U00V	KC2021	10	25.84229702	17	41.52	+10	20	42.9	18.6 VqEU091J69	
K21U00V	KC2021	10	25.84635002	17	42.08	+10	22	35.6	18.3 VqEU091J69	
K21U00V	KC2021	10	25.84770202	17	41.22	+10	23	00.6	18.6 GVEU091Z99	
K21U00V	KC2021	10	25.84820402	17	41.81	+10	24	04.1	18.2 GVEU091203	
K21U00V	KC2021	10	25.85000002	17	41.54	+10	24	04.5	18.3 GVEU091Z99	
K21U00V	KC2021	10	25.85040502	17	42.63	+10	24	28.2	18.5 VqEU091J69	
K21U00V	KC2021	10	25.85225902	17	41.90	+10	25	06.8	18.3 GVEU091Z99	
K21U00V	KC2021	10	25.85445902	17	43.19	+10	26	21.1	18.3 VqEU091J69	
K21U00V	KC2021	10	25.85672502	17	42.73	+10	28	01.7	18.1 GVEU091203	
K21U00V	KC2021	10	25.85851502	17	43.73	+10	28	14.1	18.2 VqEU091J69	
K21U00V	KC2021	10	25.87554902	17	45.51	+10	36	13.5	18.3 GVEU091Z80	
K21U00V	KC2021	10	25.88005602	17	46.10	+10	38	21.2	18.3 GVEU091Z80	
K21U00V	KC2021	10	25.88474302	17	46.71	+10	40	36.0	18.6 GVEU091Z80	
K21U00V	KC2021	10	25.95383102	17	55.45	+11	15	25.1	17.8 GXEU091958	
K21U00V	KC2021	10	25.95718802	17	55.73	+11	17	06.6	18.2 GXEU091958	
K21U00V	KC2021	10	25.96064902	17	56.04	+11	18	51.9	18.3 GXEU091958	

Observer details:
073 Bucharest. Observers D. Bertesteanu, M. Popescu, B. A. Dumitru. Measurer M. Popescu.
203 GiaGa Observatory. Observers S. Foglia, G. Galli. Measurer G. Galli. 0.36-m f/5.76 Schmidt-Cassegrain + CCD.
703 Catalina Sky Survey. Observer D. Rankin. Measurers E. J. Christensen, G. A. Farneth, D. C. Fuls, A. R. Gibbs, A. D. Grauer, H. Groeller, R. A. Kowalski, S. M. Larson, G. J. Leonard, D. Rankin, R. L. Seaman, F. C. Shelly, K. W. Wierzbos. 0.68-m Schmidt + 10K CCD.
958 Observatoire de Dax. Observer P. Dupouy. 0.32-m Schmidt-Cassegrain + CCD.

Example of Minor Planet Electronic Circular

Results: photometry

~of small bodies from the Solar System (asteroids and comets) ~

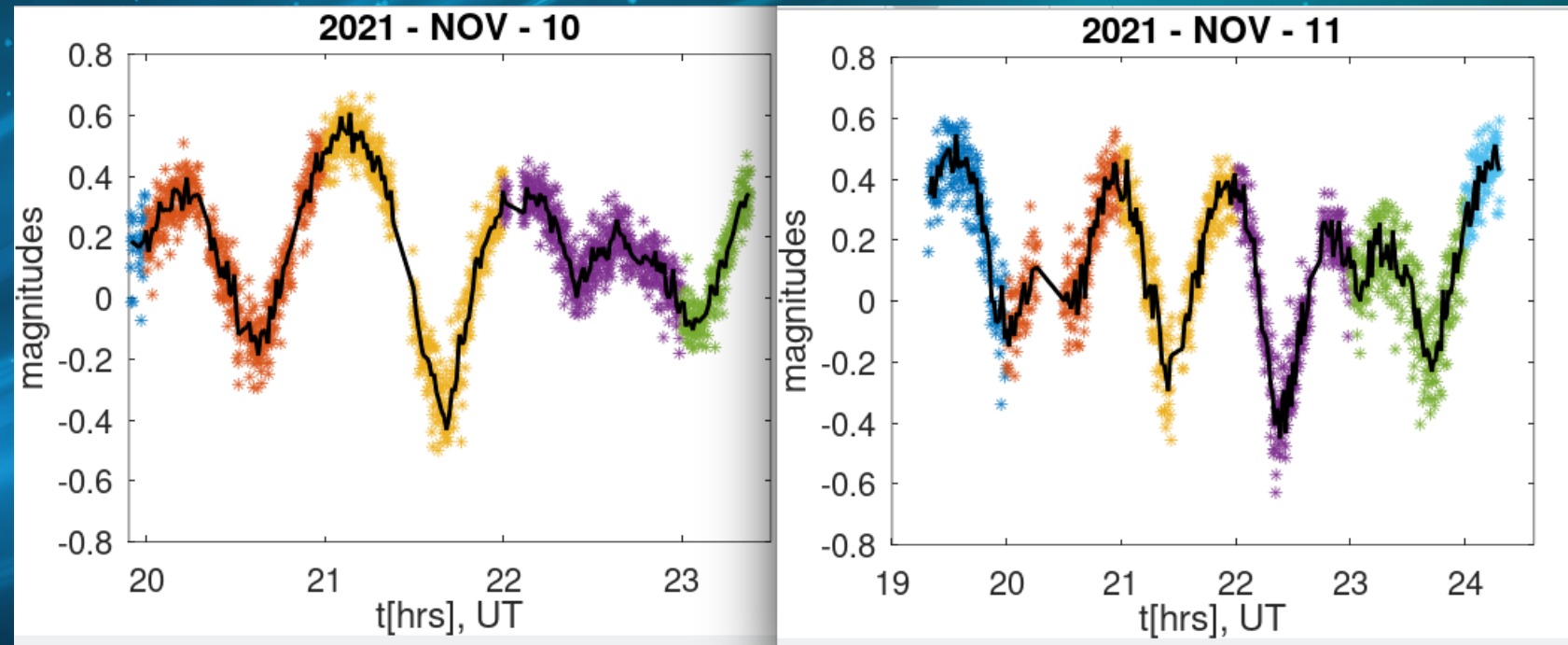
→ We obtained the lightcurves of four near-Earth asteroids (NEAs) with an apparent magnitude brighter than 17 mag: (4660) Nereus, (153591) 2001 SN263, (12711) Tukmit, and 2019 XS.

→ Observing campaign for (4660) Nereus with more than 65 hours of observations of its lightcurve. The results are presented by Mansour et al. EPSC 2022 (Poster area Level 2, L2.18).

→ One of the challenging observation was obtained during the nights of November 10 and 11 2021 for the small NEA 2019 XS (absolute magnitude of 23.87).

→ The object moved with an apparent rate of 20-30 arcsec/min, so we could use an exposure time of 5-10 sec per image and we had to change the field several times during the night.

→ The result shown strong evidences that 2019 XS is a tumbler asteroid.



The light-curves obtained for 2019 XS. The different colors correspond to different fields of view, and the black line is a box median of every 9 points.

Results: photometry

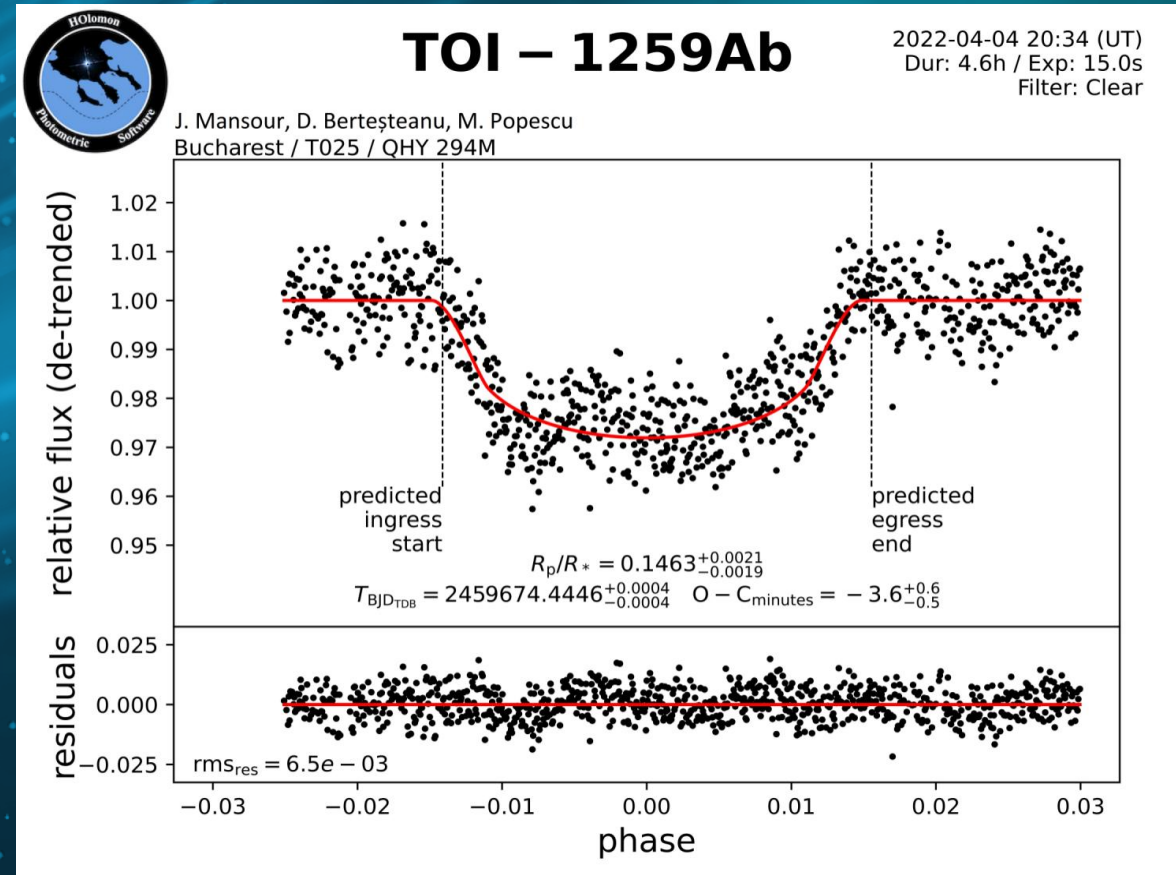
~of exoplanets~

→ High accurate measurements were obtained for characterizing the transit of exoplanets

→ A precision in the range of 0.01 magnitudes is obtained for targets as faint as 13 V mag.

→ The observations sent to Exoplanet Transit Database, <http://var2.astro.cz/EN/tresca/transits.php>, (three transits reported up to now)

→ The HOlon Photometric Software (HOPS) was used for data reduction and data analysis



The transit of TOI-1259Ab exoplanet observed with T025-BD4SB. Apparent V magnitude of the star is 12.08 (Martin et al. 2021)

Conclusions

- The T025-BD4SB is a pro-am collaboration which uses a robust instrument for:
 - astrometric observations of asteroids and comets, prioritizing the newly discovered NEAs or those with uncertain orbits;
 - photometric observations of Solar System bodies with the aim to obtain accurate light-curves for deriving the spin-properties and their shape;
 - the occultations which are performed in various international campaigns;
 - follow-up of various exoplanets transits;
 - light-curves of variable stars;
 - spectral properties of bright celestial objects.
- The project is developed by researchers from Astronomical Institute of the Romania Academy, by astronomers from Astroclubul București, and by students from Faculty of Physics from Bucharest
- It aims to attract students and amateurs astronomers for using the telescope as a learning facility and for contributing to scientific studies.