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SSAU'S ACTIVITIES IN NEO OBSERVATIONS IN 2019-2024

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Abstract

The first NEO observations were conducted in 2017 using the new wide-field telescope of the “Sazhen-S” quantum-optical station of the National space Facilities Control and Test Center (NSFCTC) of the State Space Agency of Ukraine. Regular observations, including the follow-up of new objects discoveries, began in 2019. By the end of 2024, three telescopes of NSFCTC in different parts of Ukraine have already been participating in such observations.

Despite the fact that NEO observations are not the main task of these optical sensors, more than 15,000 observations of various NEOs were obtained in the period of time from 2017 to 2024, and participation was taken in follow-up of the discovery of more than 250 new NEOs, including more than 10 PHAs.

The software tools for automatic planning of observations and analysis of the obtained results as well as the software for processing NEO observations were developed.

In the future, it is planned to increase the limited magnitude of the telescope to expand the capabilities to follow-up the discovery of new NEOs.

Keywords: NEO, optical observations, follow-up

1. Introduction

Optical observations of small bodies of the Solar System, including near-Earth objects (NEOs), began at the National Space Facilities Control and Test (NSFCTC) of the State Space Agency of Ukraine (SSAU) in 2010 as part of the participation of the NSFCTC's AZT-8 telescope in the GAIA Follow-Up Network – Solar System Objects (GAIA FUN-SSO) [1]. In particular, in 2013, a participation was taken in the campaign of optical observations of the asteroid Apophis in 2013 [2, 3]. Due to well-known political circumstances, these observations were halted in early 2014 and not resumed. The next observations of NEOs began in 2017 using the modernized wide-field telescope of the quantum optical station "Sazhen-S" (QOS-WFoV). The relatively successful observations of the 2014 JO25 [4] served as the basis for obtaining the International Astronomical Union Minor Planet Center (IAU MPC) observatory code L18 [5]. More or less regular observations began in 2019, so it was taken by the authors as the initial one. Following the commissioning of new NSFCTC telescopes in 2020–2022, they also joined these observations. In addition, two new IAU MPC codes were obtained: L99 for the Novosilky observatory [6] and M32 for the "Sunny Transcarpathian" observatory [7].

2. Instruments

2.1 QOS Observatory (L18)

The QOS Observatory received the IAU MPC code in 2017. NEO observations are conducted using two telescopes: KOS-FoV (Fig. 1a)) and the new Newtonian telescope OEOS-1 (Fig. 1b)), which began observations in 2020. Since then, most observations of the NEO have been performed using the OEOS-1 telescope, the largest SSAU telescope used for this task. The main characteristics of both telescopes are presented in Tab. 1.


a)


b)

Fig. 1. Telescopes of the QOS Observatory (L18): QOS-FoV (a) та OEOS-1 (b).

Table 1
Main characteristics of the telescopes of the QOS Observatory (L18).

	QOS (Wide FoV only)	OEOS-1
Aperture, cm	30	50
Focal length, m	0.3	3.8
Camera (chip)	CMOS	Interline CCD
FoV	130'x80'	64.8′ x 43′
Scale, "/pix	4.0	1.7 (with bining)
Mount	Equatorial	Equatorial fork
Slew rate, deg/s	Up to 2.5	Up to 5

2.2 Novosilky Observatory (L99)

The telescope at the Novosilky Observatory (L99) (Fig. 2a)) is an analogue of the QOS-WFoV on a separate equatorial mount with a direct drive. Its main characteristics are shown in Table 2.

2.3 «Sunny Transcarpathian» Observatory (M32)

«Sunny Transcarpathian» Observatory (M32, Fig. 2b)) is equipped with the newest telescope among those considered. The telescope has two different lenses, but for observations of the NEO only one of them is used, the characteristics of which can be seen in Tab. 2.

a) b)

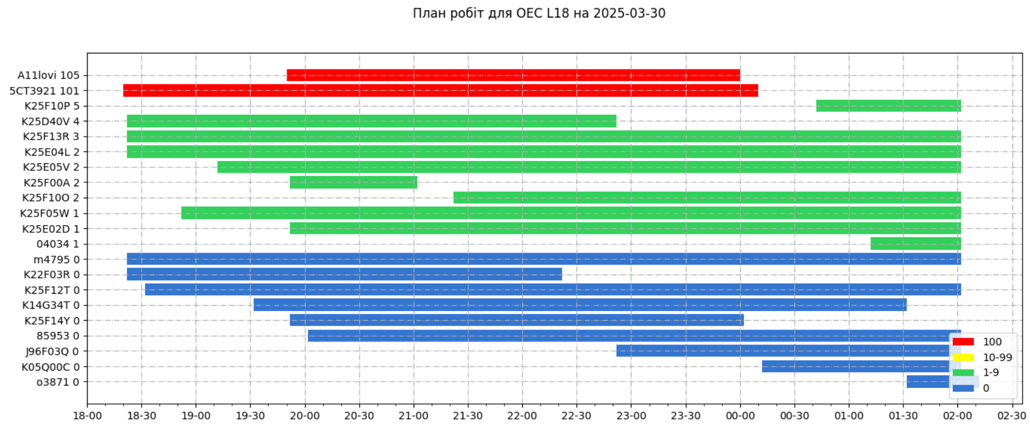
Fig. 2. Telescopes of the observatories L99 (a) and M32 (b).

Table 2
Main characteristics of the telescopes of the L99 and M32 observatories.

	L99	M32
Aperture, cm	30	35
Focal length, m	0.3	0.7
Camera (chip)	CMOS with GPS	CMOS with GPS
FoV (deg^2)	130'x80'	55'x35'
Scale, “/pix	4.0	1.7
Mount	Equatorial with Direct Drive	Equatorial with Direct Drive
Slew rate, deg/s	Up to 10	Up to 20

3. Observations planning

Initially, observation planning was performed almost entirely manually. However, with the increase in the number of telescopes and the growing need for a rapid response to the detection of new NEOs that require confirmation of discovery, a custom software package was developed — NOAP (NEO Observation Analyzer and Planner) [8].The "Planner" pipeline from this package in a fully automatic mode selects NEOs for observation, calculates their ephemeris and the observation mode (number of frames and exposure), based on the location of the telescope and its characteristics (Fig. 3). Starting from version 0.6.5, the "Planner" is able to plan observations in batch mode, sequentially for several specified observatories [9]. Also, with this version, testing of a new algorithm for determining NEOs that can be observed, depending on their ratio "apparent velocity - apparent magnitude", began for L18.



a)

NAME	PR	START	END
5CT3921	101	2025-03-30 18:20:00	2025-03-31 00:10:00
A11lovi	105	2025-03-30 19:50:00	2025-03-31 00:00:00
K25D40V	4	2025-03-30 18:22:00	2025-03-30 22:52:00
K25F10P	5	2025-03-31 00:42:00	2025-03-31 02:02:00
K25F13R	3	2025-03-30 18:22:00	2025-03-31 02:02:00
K25E04L	2	2025-03-30 18:22:00	2025-03-31 02:02:00
K25F10O	2	2025-03-30 21:22:00	2025-03-31 02:02:00
K25E05V	2	2025-03-30 19:12:00	2025-03-31 02:02:00
K25F00A	2	2025-03-30 19:52:00	2025-03-30 21:02:00
K25F05W	1	2025-03-30 18:52:00	2025-03-31 02:02:00
K25E02D	1	2025-03-30 19:52:00	2025-03-31 02:02:00
K25F14Y	0	2025-03-30 19:52:00	2025-03-31 00:02:00
K25F12T	0	2025-03-30 18:32:00	2025-03-31 02:02:00
K22F03R	0	2025-03-30 18:22:00	2025-03-30 22:22:00
K05Q00C	0	2025-03-31 00:12:00	2025-03-31 02:02:00
85953	0	2025-03-30 20:02:00	2025-03-31 02:02:00
04034	1	2025-03-31 01:12:00	2025-03-31 02:02:00
m4795	0	2025-03-30 18:22:00	2025-03-31 02:02:00
K14G34T	0	2025-03-30 19:32:00	2025-03-31 01:32:00
J96F03Q	0	2025-03-30 22:52:00	2025-03-31 02:02:00
o3871	0	2025-03-31 01:32:00	2025-03-31 02:12:00

b)

A11lovi
Priority: 105

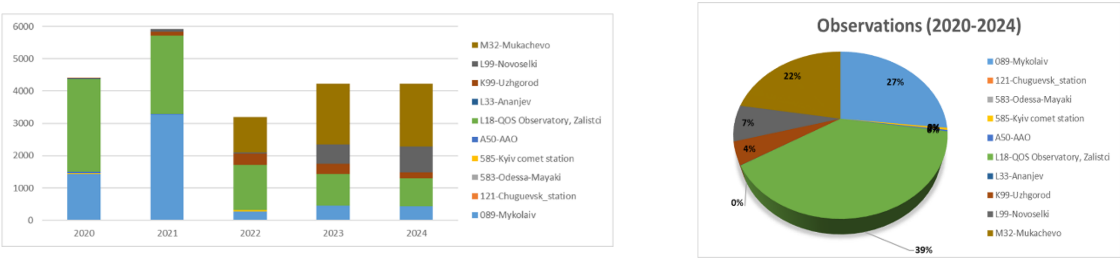
Date	UT h m	*	R.A. (J2000)	Decl.	Elong.	V	Motion "/min	P.A.	Object Azi.	Alt.	Sun Alt.	Phase	Moon Dist.	Alt.	Uncertainty		Exp, s	Frames
2025 03 30	1950		12 18 28.7	-14 09 27	168.8	18.7	8.49	081.4	327	+21	-29	0.03	159	-12	Map/Offsets	!	10	95
2025 03 30	2000		12 18 34.4	-14 09 14	168.9	18.7	8.48	081.2	329	+22	-30	0.03	159	-13	Map/Offsets	!	10	95
2025 03 30	2010		12 18 40.2	-14 09 01	168.9	18.7	8.48	081.0	331	+23	-31	0.03	159	-14	Map/Offsets	!	10	95
2025 03 30	2020		12 18 45.9	-14 08 48	168.9	18.7	8.48	080.9	334	+24	-32	0.03	159	-15	Map/Offsets	!	10	95
2025 03 30	2030		12 18 51.7	-14 08 34	168.9	18.7	8.48	080.7	337	+24	-33	0.03	159	-16	Map/Offsets	!	10	95
2025 03 30	2040		12 18 57.4	-14 08 21	168.9	18.7	8.49	080.6	339	+25	-33	0.03	159	-17	Map/Offsets	!	10	95
2025 03 30	2050		12 19 03.2	-14 08 07	168.9	18.7	8.50	080.4	342	+25	-34	0.03	159	-18	Map/Offsets	!	10	95
2025 03 30	2100		12 19 09.0	-14 07 52	168.9	18.7	8.51	080.2	344	+26	-35	0.03	159	-19	Map/Offsets	!	10	95
2025 03 30	2110		12 19 14.7	-14 07 38	169.0	18.7	8.52	080.1	347	+26	-35	0.03	158	-20	Map/Offsets	!	10	95
2025 03 30	2120		12 19 20.5	-14 07 23	169.0	18.7	8.54	079.9	350	+27	-36	0.03	158	-21	Map/Offsets	!	10	95
2025 03 30	2130		12 19 26.3	-14 07 08	169.0	18.7	8.56	079.8	352	+27	-36	0.03	158	-22	Map/Offsets	!	10	95
2025 03 30	2140		12 19 32.1	-14 06 52	169.0	18.7	8.59	079.6	355	+27	-37	0.03	158	-22	Map/Offsets	!	10	95
2025 03 30	2150		12 19 37.9	-14 06 37	169.0	18.7	8.62	079.5	358	+27	-37	0.03	158	-23	Map/Offsets	!	10	95
2025 03 30	2200		12 19 43.8	-14 06 21	169.0	18.7	8.65	079.3	000	+27	-37	0.03	158	-24	Map/Offsets	!	10	95
2025 03 30	2210		12 19 49.6	-14 06 05	169.0	18.7	8.69	079.2	003	+27	-37	0.03	158	-24	Map/Offsets	!	10	95
2025 03 30	2220		12 19 55.5	-14 05 48	169.0	18.7	8.73	079.1	006	+27	-37	0.03	158	-25	Map/Offsets	!	10	95
2025 03 30	2230		12 20 01.4	-14 05 32	169.1	18.7	8.78	079.0	008	+27	-37	0.03	158	-25	Map/Offsets	!	10	95

c)

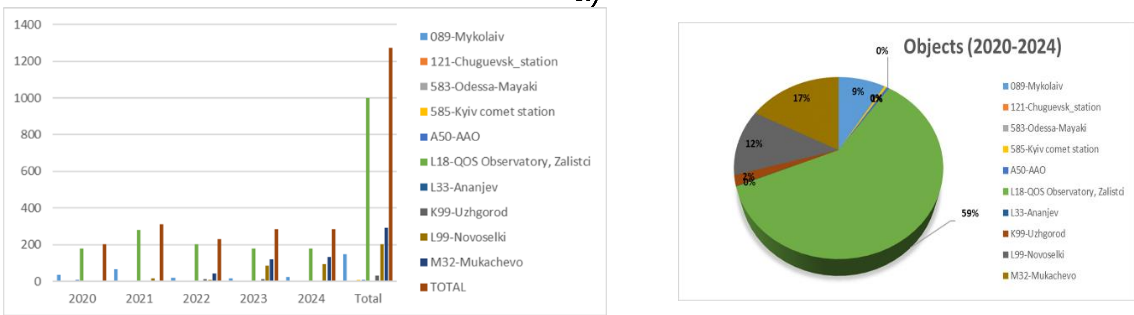
Fig. 3. Results of the "Planner" pipeline: observation plan for the observatory for one night in graphical (a) and textual (b) forms and the ephemeris with the calculated observation mode for one NEO (c).

4. Results

According to the NEODyS-2 website [10], as of March 17, 2025, for the years 2019–2024 (i.e. since the start of regular observations of NEOs), the L18, L99, and M32 observatories received 15,395 observations of more than 1,200 NEOs. During this time, these observatories participated in the confirmation of the discovery of 266 NEOs (including 11 potentially hazardous asteroids, PHA) and 2 long-period comets. Of these, 246 NEOs (11 PHA) and 2 long-period comets were confirmed by the L18 observatory.

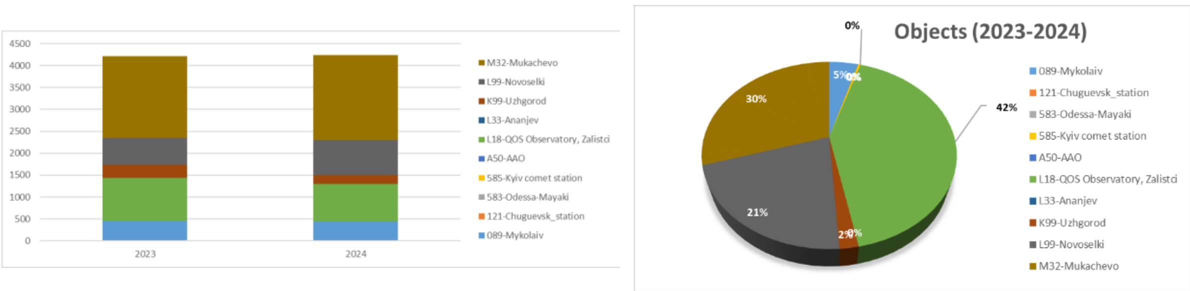


a)

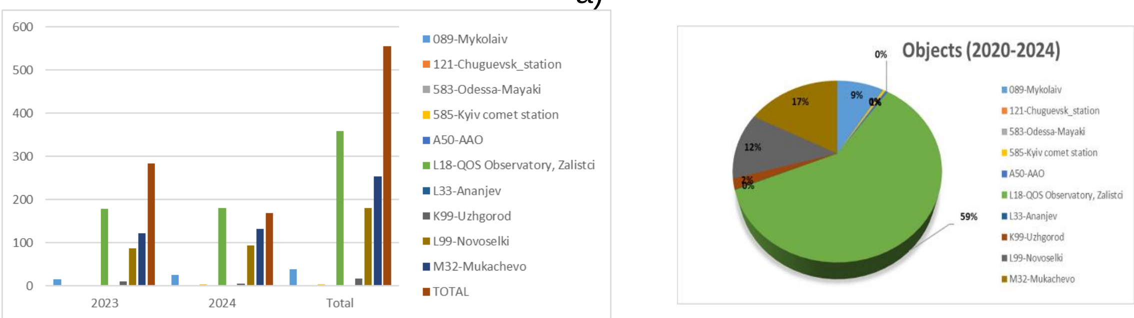


b)

Fig. 4. Number of NEO observations (a) and number of NEO (b) observed by Ukrainian observatories in 2020-2024 according to data [10] as of March 17, 2025. The data were obtained using the "Analyzer" pipeline from the NOAP package [8].



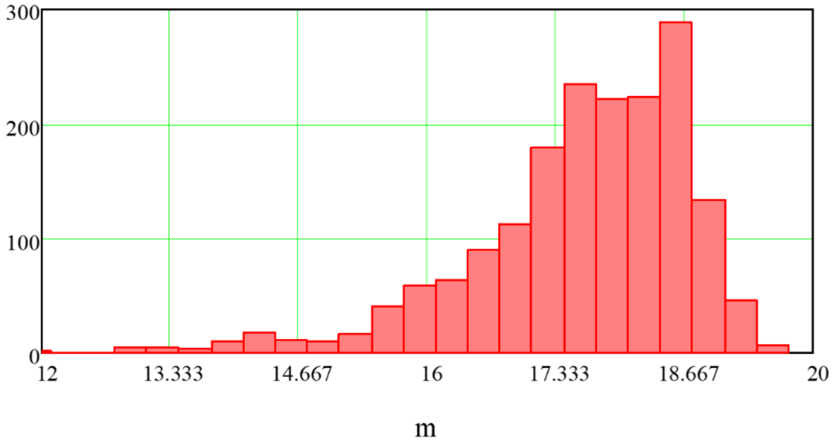
a)



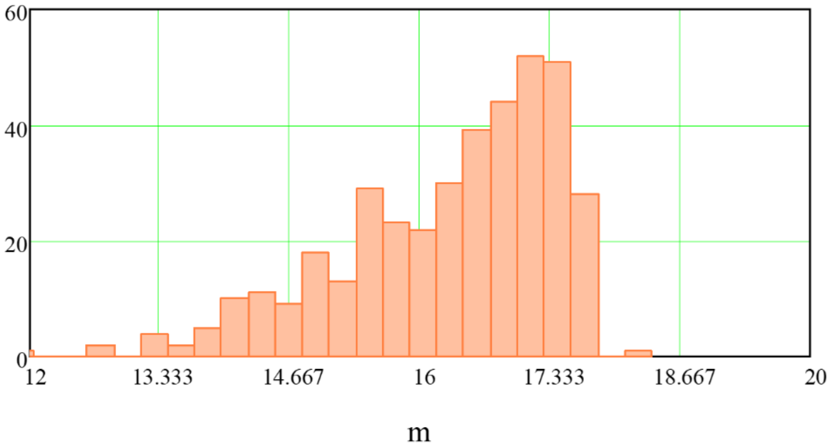
b)

Fig. 5. Number of NEO observations (a) and number of NEO (b) observed by Ukrainian observatories in 2023-2024 according to data [10] as of March 17, 2025. The data were obtained using the "Analyzer" pipeline from the NOAP package [8].

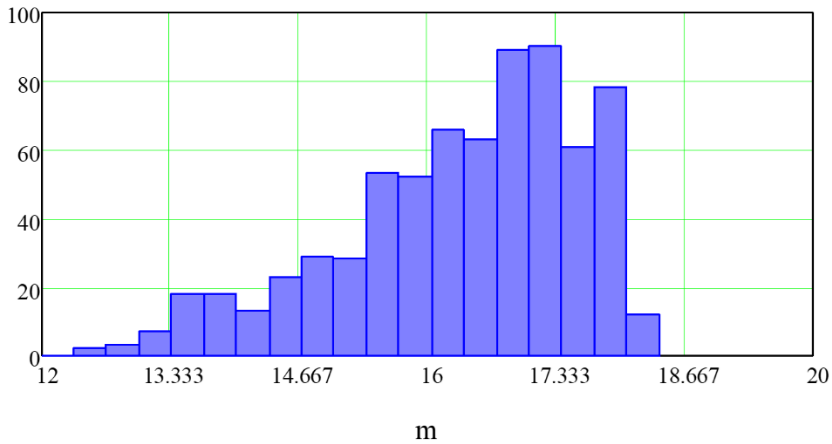
The distribution of NEOs observed in the telescopes of the SSAU from 2019 to 2024 is presented in Fig. 6.



L18



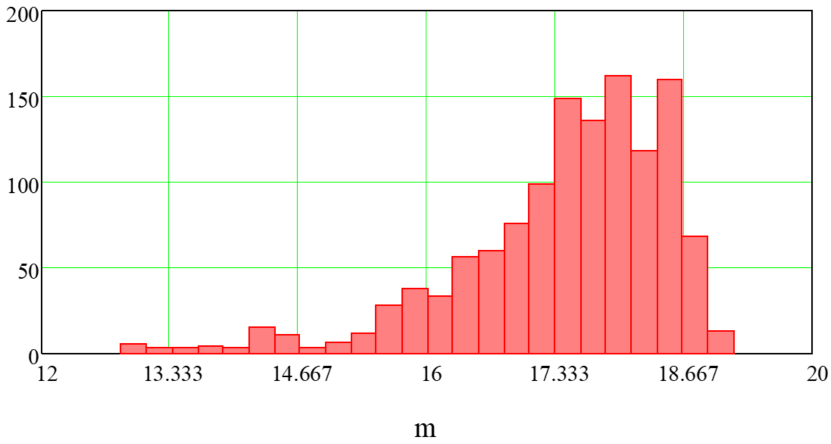
L99



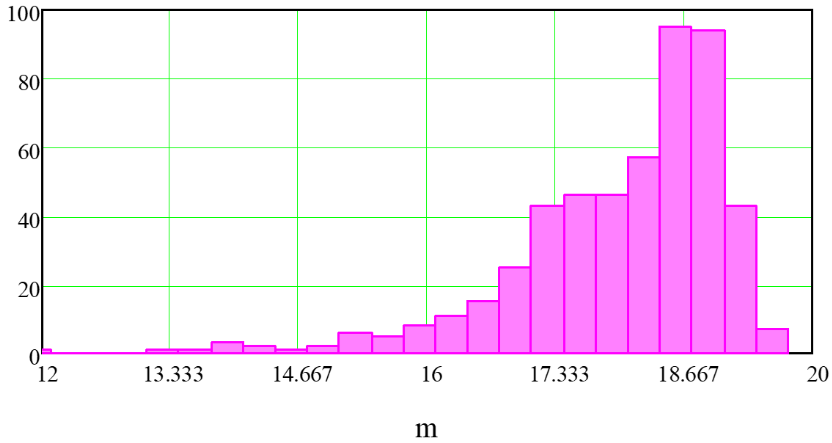
M32

Fig. 6. Distribution of NEOs observed by SSAU telescopes in 2019-2024, by apparent magnitude.

An analysis of Figs. 4–6 clearly shows that the L18 observatory has made the most significant contribution to the overall results, particularly in terms of the total number of observed NEOs.L18 also accounts for the majority of confirmations of the discovery of new NEOs: 246, including all potentially dangerous ones. This is primarily due to the fact that the OEOS-1 telescope of this observatory is the largest of the SSAU telescopes involved in observing NEOs (see Table 1-2), i.e. it can observe much fainter NEOs than others. Testing of the new NEO selection algorithm for observations in the “Planner” pipeline demonstrated that its implementation led to an approximate 0.5 magnitude increase in the limiting brightness of observable NEOs (Fig. 7, [9]).



2019 - 2022



2023-2024

Fig. 7. Distribution of NEOs observed by the L18 observatory by apparent magnitude before (2019 – 2022) and after (2023 – 2024) the introduction of a new algorithm for selecting observation objects.

5. Conclusions and plans for the future

Between 2019 and 2024, the SSAU significantly increased its activity in the field of positional observations of NEOs, primarily through the increase in the number of observing telescopes. It participated in the confirmation of the discovery of more than 250 new NEOs, including 11 PHA’s.

The introduction of a software pipeline has significantly simplified the process of planning NEO observations for several observatories due to its full automation.
Looking ahead, further improvements to the observation planning software are anticipated. In addition, the most effective instrument - OEOS-1 is planned to be upgraded by replacing its camera with a CMOS camera with higher quantum efficiency. We hope that this will allow this telescope to observe NEOs with an apparent brightness of up to 20^m.

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