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Gaia-FUN-SSO at the Konkoly Observatory: First Results and the Prospects for Future Work

Krisztián Sárneczky, László L. Kiss, László Szabados

*Konkoly Observatory, Research Centre for Astronomy and Earth Sciences,
Hungarian Academy of Sciences, Budapest, Hungary*

Introduction

The Konkoly Observatory is the largest astronomical institute in Hungary. It is now a part of the Research Centre for Astronomy and Earth Sciences of the Hungarian Academy of Sciences. The main observing station is the Pizskéstető Observatory located in the Mátra mountains, about 80 km from the headquarters to NE direction at about 950 m above the sea level.

The current observing equipments in the Pizskéstető Mountain Station are as follows:

- 0.5 m Cassegrain-type telescope, equipped with a photoelectric photometer. This telescope has been used for observing bright variable stars (up to about 11th magnitude in V).
- 0.6 m Schmidt-telescope, used for wide-field imaging. In the photographic era, it had a 5-degree field of view and was very successful in discovering comets and supernovae. This was the first telescope in Pizskéstető, installed in 1962.
- 1 m Ritchey-Chrétien-Coudé telescope, used for photoelectric and CCD photometry.
- 0.4 m RC telescope installed in 2010. The main program carried out with this remotely controlled small telescope is CCD photometric follow-up of known transiting exoplanets but we also envisage studies of minor objects in the Solar System.

Both the 0.6 m Schmidt and the 1 m RCC telescopes will be upgraded to remote-controlled instruments, meaning that the reaction time to rapid alerts will be sufficiently short.

These telescopes (except the smallest one) were manufactured by Carl Zeiss Jena. While the telescope mounts are still the original ones, the control systems in the Schmidt and the RCC have been upgraded several times over the years. As of writing, all of these telescopes are regularly used for CCD imaging, equipped with various CCD cameras (including an EMCCD camera) that are partly interchangeable between the 0.5 m Cassegrain and the 1 m RCC telescopes.

Scientists affiliated with the Konkoly Observatory have been involved in studies of:

- variable stars: stellar pulsations, asteroseismology (ground based as well as space photometry by CoRoT and Kepler), stellar activity, eclipsing binaries;
- interstellar matter, star formation (in addition to ground based data, studies in infrared based on data obtained with the instruments on board ISO, Spitzer, and Herschel space probes);
- small bodies in the Solar System (ground based astrometry, comets studied with HST and Spitzer, trans-Neptunian objects with Herschel);
- exoplanets (both ground- and space-based photometric observations).

1. Astrometric results

The most effective astrometric instrument is the 60/90/180 cm Schmidt telescope that was equipped with a Photometrics 1.5k × 1k CCD camera between 1996 and 2010. In 2010, this

camera was replaced by an Apogee Alta U16 4k × 4k CCD camera, with a $1.2^\circ \times 1.2^\circ$ field of view. This corresponds an increase by a factor of 10 in the imaged sky area, resulting in a dramatic jump in survey efficiency.

There has been a very successful astrometric program at the Konkoly Observatory since 1998. The observations have been reported under the Minor Planet Center observatory code 461 [1]. 19-20th magnitude near-Earth asteroids have regularly been captured with the Schmidt, indicating that the sensitivity reaches the expected limits of Gaia. With the recently upgraded CCD system, the efficiency has improved by over an order of magnitude, making our telescope a potentially very useful instrument for Gaia Solar System follow-up.

In the framework of the Gaia-FUN-SSO we took part in each campaign in 2011 and 2012. The summary of observations is given in the following tables.

1.1 Campaign on (308635) 2005 YU55

Date	Magnitude	Motion	Tel.	Exp. time	Number of positions	Residuals in arc sec	
9 Nov. 2011	11.5 R	44"/min	60S	3 sec	36	0.3" RA	0.1" Dec
12 Nov. 2011	14. R	2.7	60S	60 sec	12	0.3" RA	0.4" Dec
15 Nov. 2011	16.0 R	0.9	60S	90 sec	9	0.2" RA	0.3" Dec
17 Nov. 2011	16.5 R	0.6	60S	90 sec	3	0.1" RA	0.3" Dec
22 Nov. 2011	17.8 R	0.3	60S	120 sec	3	0.2" RA	0.4" Dec
23 Nov. 2011	17.9 R	0.3	60S	120 sec	3	0.2" RA	0.4" Dec
27 Nov. 2011	18.7 R	0.3	60S	120 sec	2	0.5" RA	0.5" Dec
28 Nov. 2011	18.9 R	0.3	60S	120 sec	2	0.2" RA	0.3" Dec
29 Nov. 2011	19.0 R	0.3	60S	120 sec	2	0.2" RA	0.4" Dec
30 Nov. 2011	19.0 R	0.3	60S	120 sec	3	0.3" RA	0.4" Dec

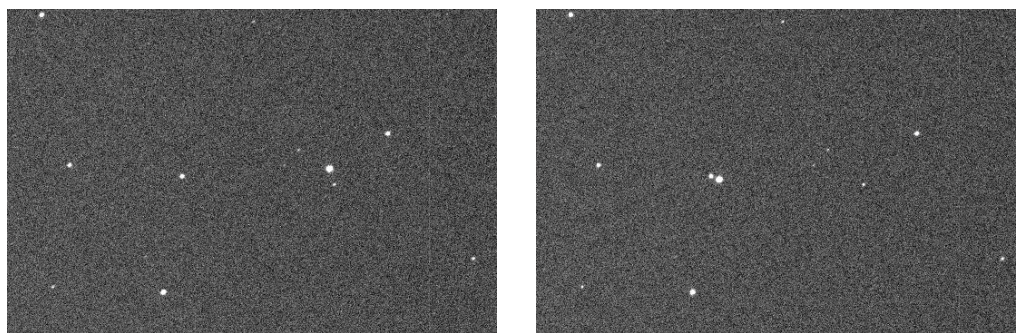


Fig. 1: Two images of (308635) 2005 YU55

1.2 Campaign on TP3522 = 2012 BS67

Date	Mag.	Motion	Tel.	Exp. time	Number of positions	Residuals in arc sec	
25 Jan 2012	19.5 R	0.6"/min	60S	150 sec	3	0.3" RA	0.7" Dec

From the observations available in January 2012, K. Sárneczky determined the orbital elements of this asteroid, including the moment of the perihelion passage: 2012 Mar 22.56993 TT.

1.3 Campaign on (175706) 1996 FG3

Date	Magnitude	Motion	Tel.	Exp. time	Number of positions	Residuals in arc sec	
23 Mar 2012	20.1 R	1.1"/min	102RC	10×60 sec	4	0.3" RA	0.7" Dec

1.4 Campaign on (99942) Apophis

Date	Magnitude	Motion	Tel.	Exp. time	Number of positions	Residuals in arc sec	
23 Mar 2012	20.8 R	2.2"/min	102RC	10×60 sec	3	0.3" RA	0.7" Dec
23 Mar 2012	20.9 R	2.2"/min	102RC	12×60 sec	3	0.3" RA	0.7" Dec

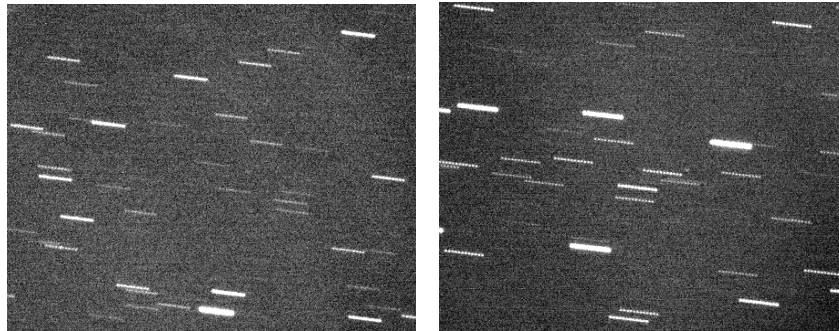


Fig. 2: Two consecutive observations of Apophis

1.5 Summary of astrometric observations at Pizskéstető

Statistics of astrometric data since Sept. 2010, our last report [1]:

49455 accurate positions were determined on 8967 asteroids and 17 comets;

1281 newly designated objects, 4 new NEOs were detected, as well as 1487 one-night stands by 20 observers involved in the Konkoly Gaia-FUN-SSO project.

2. Our other involvement in the Gaia project

Our current involvement in the Gaia preparations includes the work carried out by the Konkoly Observatory Gaia Team (KOGT). The KOGT has been involved in the following projects:

- CU7 Specific Object Studies Working Group (Cepheids & RR Lyrae stars Work Package, secular evolution Work Package);
- DPAC Ground Based Observations for Gaia;
- Gaia Science Alerts Working Group;
- Gaia Research for European Astronomy Training (GREAT): Gaia Alerts (WGA5), Distance Scales (WGA8), Stellar Variability (WGB2), Binaries & Multiple Systems (WGB3).

These studies have been supported by ESA and the Hungarian Space Office, through the PECS programme.

In the Cepheid related studies, our main task is to reveal companions to Cepheids by photometric and/or spectroscopic observations. Binarity of Cepheids is an important aspect because physical companions can falsify the trigonometric parallax in the astrometric solution. We have pointed out that all negative Hipparcos parallaxes of Cepheids within 2 kpc belong to those stars which are members in known binary (or multiple) systems.

We initiated a photometric search for close visual companions of Cepheids by lucky imaging technique with an EMCCD camera at the 50 cm Cassegrain telescope. Figure 3 visualizes the improvement in the angular resolution using this technique, via the example of CE Cas, a double Cepheid, whose both components are Cepheid variables with a 2.3" separation.



Fig. 3: Improvement of imaging by the lucky image technique: the binary Cepheid CE Cas (*left*: without lucky imaging; *right*: with lucky imaging)

Conclusion

With the telescopes at the Piszkestető Mountain Station we took part in observing each target suggested for following in the Gaia-FUN-SSO alert system. Our observations belong to the faintest ones (up to 21st magnitude), i. e., the latest data on targets reported by the contributors to the Gaia-FUN-SSO project. During the active period of the Gaia spacecraft we plan to be involved in the Gaia alerts with observing transient astrophysical object/phenomena at short notice.

The recently completed and planned upgrades in instrumentation make the site very suitable to provide astrometric support to Gaia. Providing a ground based photometric and astrometric support for the Gaia, the most important space project of this decade allows the Konkoly Observatory to contribute to the cutting-edge research.

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Reference

[1] Kiss, L. L., Sárneczky, K. 2011, Proc. of the Gaia-FUN-SSO Workshop No. 1., eds. P. Tanga & W. Thuillot, IMCCE-Paris Observatory, pp. 111-114.