IAU Working Group -Astrometry by Small Ground Based Telescopes

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Annual Report 2019

The WGASGBT (Working Group on Astrometry by Small Ground Based Telescopes) was set up in 2006 during the XXVIth IAU General Assembly in Prague by the Division 1 (Fundamental Astronomy). Since then it has been successively extended. The last triennium extension by Division A occurred during the XXXth IAU General Assembly held in Vienna in 2018. The goal of this WG is to update and maintain information on astrometric programmes and activities carried out with small telescopes, to diffuse news through these pages and by e-mails, to facilitate the collaborations and to help for the coordination of the activities, when possible, in astrometry from ground-based telescopes of D < 2 m. These telescopes are generally easier to access than larger ones and allow us to carry out observational programs on medium and long term. Thanks to that they are precious tools to contribute to the advance of our knowledge of the celestial bodies: many Solar System objects and some astrophysical objects. More generally, the small telescopes due to their number and their geographical spread, are very efficient for observation in network. This is a strength which is successfully applied for coordinated programs.

Here it follows a brief summary of our activities in 2019.

W. Thuillot reports that during he and his colleagues at IMCCE, Paris Observatory, France, worked in the validation and follow-up of the Gaia discoveries of Solar System Objects, acquisition and exploitation of astrometric observations of natural satellites and set up of a new astrometric project by exploitation of old photographic plates. The Gaia alerts Follow-Up Network, Gaia-FUN-SSO (Thuillot et al., 2018b), continued to react on alert when new Solar System Objects were detected by Gaia. An alert pipeline is operating since the end of 2016 and transforms the Gaia space data into propagated topocentric data which are diffused at the address https://gaiafunsso.imcce.fr. Around 1500 alerts per year (4 alerts/day) are triggered. The detection of more than 200 new objects have already been reported and their astrometric data have been sent to the Minor Planet Center in order to feed the asteroid orbital database. The most productive observatories are the 1m class

telescopes of the Las Cumbres Observatory Global Telescope network, Haute-Provence Observatory, Odessa-Mayaki, Terskol and Caussols (Thuillot et al., 2019; Carry et al., 2019; Thuillot & Dennefeld, 2018a). The data issued from the last campaign of observation of mutual events of the Galilean satellites, eclipses or occultations of satellites by each other, coordinated by IMCCE and the Sternberg Astronomical Institute in Moscow have been analyzed (Saquet et al., 2018; Zhang et al., 2019). This kind of photometric observations are made for astrometric purposes. They are performed by small telescopes and lead to very accurate astrometric measurements which are used in the dynamical development of the natural satellite models. New predictions have been made and new campaigns are foreseen (Arlot & Emelyanov, 2019). Besides, the NAROO project anticipated the use of the Gaia stellar catalogs to rereduce old photographic plates (Arlot, Robert & Lainey, 2018; Arlot & Robert, 2019; Robert et al., 2019). A sub-micrometric scanning machine has been set up in Paris Observatory for this goal and begun to operate in 2019. W. Thuillot also points out to a report from N. Mason, President of the Europlanet Society and coordinator of the Europlanet 2024 RI Section. N. Mason reported that Europlanet 2024 RI is establishing a network of small telescope facilities within Europe and beyond. A full-day virtual meeting was held in March 2020 to officially kick-off the activity. The web-conference was attended by 37 participants representing Europlanet 2024 RI and the Work Package team but also a diverse set of different telescope facilities from all over Europe. The main goal of the meeting was to discuss the aims and goals of the network activity for the upcoming four years. These contain the development of a central website for observational alerts and the organization of coordinated campaigns, amateur training workshops, and the establishment of the Europlanet Telescope Network itself.

N. Zacharias submitted a full report on US Naval Observatory activities for Comission A1 which does include topics for the WGASGBT. He recently released a public report about the 1-meter telescope of the USNO, the Deep South Telescope (DST), deployed at Cerro Tololo Interamerican Observatory (CTIO), Chile in March 2019. A 4k CCD camera will be used to image selected optical counterparts of ICRF sources which display significant radio-optical position offsets. This high cadence observing program is a joint effort between USNO and Paris Observatory. DST will also be used for other programs in the future, including near-infrared observations with a camera mounted at the 2nd Nasmyth focus.

F. Taris reports that quasar optical flux variations can alert us to potential changes in their source structure. These changes could have important implications for the position and time

evolution of the target photocenters with consequences for the link of the reference systems (ICRF-Gaia CRF). For some targets well observed by the TAROT telescopes, the Allan time variance shows that the longest averaging period of the magnitudes is in the range 20-70 days. The observation period by Gaia for a single target largely exceeds these values, posing a problem when the magnitude variations exhibit flicker or random walk noises. Preliminary computations show that if the coordinates of the targets were affected by a white-phase noise with a formal uncertainty of about 1 mas (due to astrophysical processes that are put in evidence by the magnitude variations
of the sources), it would affect the precision of the link at the level of 50 μas (Taris et al., 2018). To improve these first results the SYRTE department of Paris observatory is involved in photometry measurements of AGNs (quasars) in the frame of several projects. They are performed with small (or medium) class telescopes in close collaboration with Belgrade, Côte d'Azur and Montsec Astronomical observatories. Magnitude time series
are continuously acquired to improve our knowledge of the longest averaging period of the magnitude time series of AGNs. The laboratory is associated with the Fundamental Reference AGN Monitoring Experiment (FRAMEx) project lead by USNO. The goal is to observe the optical counterpart of radiosources at the same time than the VLBA and IR facilities. To observe a huge amount of targets on a daily basis, the laboratory initiated the construction of a 1 m robotic telescope. Half of the budget had already been obtained and the team plan to build the instrument before autumn 2021.

R. Teixeira reports local and remote (from Shanghai, China) observations of artificial satellites and space debris made with the MEADE 40cm of the Abrahão de Moraes Observatory of the University of São Paulo, Brazil. The observations are made with a CCD camera in drift scan mode coupled to a rotator developed by the Shanghai Observatory. These observations are part of a larger project in collaboration with colleagues from various institutions around the world for the astrometry of fast objects such as artificial satellites, debris and Near-Earth Asteroids. He also reports that the CCD Meridian Circle of that observatory is currently deactivated, but opened for public outreach.

T. Pauwels reports the activities at the Royal Observatory of Belgium. In 2017 the dome of the Ukkel Schmidt Telescope was restored, and during that period no observations were possible. After the telescope was available for observations again, the number of still to be discovered asteroids in the range of the equipment (magnitude limit 20-20.5) had decreased too much to justify the cost of the maintenance and to motivate the observers. No astrometric

observations have been performed since then, and it is quite unlikely that observations will be done in the future.

N. Maigurova and O. Shulga report astrometrical observations of small Solar System bodies, multiple stars and open clusters, GEO and LEO satellites and meteors carried out by small ground-based telescopes at the Research Institute Mykolaiv Astronomical Observatory, Ukraine. A total of 1229 topocentric positions of 40 NEAs and 112 ones of 5 comets were obtained during 2019 at the KT-50 telescope. The positions were sent to the IAU MPC database (code 089). Observations of 260 open cluster fields were made in 2019 at the KT-50 telescope resulting on a catalog of 357,000 star positions up to V magnitude 16 at epoch 2019.5. Observations of 398 multiple and double stars were obtained in 2019 at the Axial Meridian Circle. The results will enter the WDS database. Optical and radio observations of meteors are under way. The observations are presented on the RMOB (Radio Meteor Observing Bulletin) website. Optical observations of low-orbiting satellites were carried out in 2019 at the KT-50 telescope. There were 686 successful observations over 25 nights. A database of 8380 positions was obtained. Optical observations of the satellites on geostationary orbits were also performed in 2019. There were 748 successful observations over 72 nights. A database of 15618 positions was obtained. According to the Ukrainian Network of Optical Stations in 2019, the team succeeded in contributing with positions to obtain orbital elements for the satellites, which are placed on the website http://umos.mao.kiev.ua/eng/index.php?slab=slabid-12.

Anatoliy Ivantsov reports activities supported by the Akdeniz University, Antalya, Turkey. It hosted the international workshop meeting Dynamics and Physics of Asteroids, TNOs and Natural Satellites in the New Era of Gaia Data (https://asteroid2019.space) on September 4-6, 2019. There were three sessions: Dynamics of Small Bodies, Sky Surveys from Space and from the Ground and Observations of Small Bodies, where numerous achievements in astrometry, photometry, spectroscopy, polarimetry were presented and discussed. The SOC comprised of two members of this WG (W. Thuillot and A. Ivantsov). There were more than 30 participants with 60% from Austria, China, France, Italy, Russia, Ukraine, UK, and USA. An observational programme devoted to characterizing the potentially hazardous asteroids and study their dynamics was initiated at the UBT60 telescope (D=0.61 m, F=3.96 m) of the Akdeniz University located at the Tubitak National Observatory site (A84). The telescope operated remotely is equipped with standard Johnson-Cousins UBVRcIc and SDSS filters and a new FLI Proline 16803 CCD (4096x4096, 9µm x 9µm) installed in 2019.

M. Assafin and R. Vieira Martins report on the astrometric and photometric use of 0.6m to 2.2m class telescopes at Brazil, Chile, Australia, France and Spain. They report the first observation of a stellar occultation (SO) by Europa (Morgado et al., 2019a), the observation of mutual approximations between the main satellites of Jupiter (Morgado et al., 2019b) and Uranus (Santos Filho et al., 2019), a SO by the irregular satellite Phoebe of Saturn (Gomes-Júnior et al., 2020), and SOs by Trojan asteroids of Jupiter, Centaurs (including the ringed object Chariklo), dwarf planets and many other transneptunian objects (Camargo et al., 2018). Regular astrometric observations of natural and irregular satellites of giant planets were also done with these instruments. They also report an initivative to form an astrometric/photometric network of tens of small 40-50 cm aperture telescopes in Brazil and South America - ROSA (South America Occultation Network in english) - in support but not limited to the observation of SOs by Solar System bodies, education and scientific outreach.

G. Damljanovic from the Astronomical Observatory at Belgrade (AOB), Serbia, reports that his team established a local Serbian-Bulgarian mini-network of six telescopes (lead by G. Damljanovic) at three sites: Belogradchik AO and Rozhen NAO in Bulgaria, and Astronomical Station Vidojevica (ASV) in Serbia. They observe QSOs, objects from alerts by the Gaia-FUN-TO (Gaia Follow Up Network for Transients Objects) and blazars from alerts by the WEBT-GASP (Whole Earth Blazar Telescope Project), among other objects. Near 100 ICRF QSOs, about 20 WEBT objects and about 75 Gaia Alerts were observed. About the SANU-BAN cooperation (between the Serbian Academy of Sciences and Arts and Bulgarian Academy of Sciences), there are two joint research projects underway on the observation of ICRF and Gaia radio-sources and fast variable objects, lead by G. Damljanovic. The synergy between Gaia and ground-based observations is of big importance, and it is in line with the Serbian-Bulgarian astronomical cooperation and investigation using our mini-network of six telescopes. It is important to align the Gaia frame (based on optical data) and ICRF (VLBI data) through observations of QSOs in both visible and radio domains, with a compact radio/optical core but without complex structures. Using the mini-network, the team monitors some QSOs and check the optical data (position stability and structure) via photometry and morphology investigations. The 2 m Rozhen and 1.4 m ASV telescopes are used in the QSO morphology investigations, and other telescopes (60 cm ASV, 60 cm Belogradchik, 60 cm Rozhen, and Schmidt-camera 50/70cm) are used for photometry to investigate QSOs quasi-periodicities. The WEBT is a network for optical, near-infrared, and radio observations to obtain

continuously, high-temporal-density monitoring of blazars. The WEBT data are extremely useful to understand the continuum emission of blazars. Gaia Alerts have been issued by the Gaia Science Alerts group, and Gaia is now the largest provider of transients in the world (rare types of supernovae, cataclysmic variable, microlensing events, etc.) with about 2000 alerts per year. Using our telescopes for simultaneous observations we can get data for multi-color photometric light curves and investigate fast changes on the flux of the objects. The investigations involved the reduction of CCD images for photometry/morphology, calculation of BVRI magnitudes (photometry, quasi-periodicities), determination of QSOs parameters using GALFIT software (morphology), the improvement of some steps and methods (during reduction of raw CCD images) to remove systematic errors and to get accurate data as much as possible, the development of new methods to get precise results, and the analysis of these results. The team collaborates with the Observatoire de Paris, Torino Observatory, among others. Some of our results have been published in several journals: MNRAS, Astrophysical Journal, Astrophysical Journal Letters, Astronomical Journal, Serbian Astronomical Journal, Astronomy and Astrophysics, etc. Also, some results were presented at a few conferences, and published in the Bulgarian Astronomical Journal.

Please visit our refreshed web page at https://iau_wgnps.imcce.fr for more historic and updated reports on the activities of this WG.

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