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ASTEROID OBSERVATIONS IN FRAMEWORK OF ISON NETWORK

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Introduction: Knowledge on an outer space has led to understanding the awareness of the space threat ï asteroid hazard. Research of the near-Earth asteroids (NEAs) include detecting and cataloging, investigating evolution of their orbits, and studying their physical and mineralogical properties are important now. These tasks require a scientific tool of the geographically distributed network of optical telescopes. An attempt to create such network was initiated in the project of the International Scientific Optical Network (ISON) [1]. ISON is an open international voluntary cooperation of observatories coordinated from Small Innovation Enterprise «KIAM Ballistics-service» and specializing in observations of the near-Earth space objects. The network has been working since 2005 and collaborates now with 27 observatories in 15 countries. ISON conducts asteroid researches in three main directions - developing and carrying out asteroid survey using small telescopes with large field of view (FOV); follow-up observations of newly discovered NEAs; study of the physical properties of NEAs with an emphasis on hazardous asteroids.

ISON asteroid survey: The ISON asteroid test survey started in 2010 and was aimed to develop the technology so called a survey of ñsecond waveò (large sky coverage with small limiting magnitude). The purpose of the survey was detecting asteroids and comets missed by ñdeepò asteroid surveys. In 2015-2017, survey was performed using two 40-cm telescopes - at the Mayhill (H15, USA) with FOV of 1.75° and at the Siding Spring (Q60, Australia) with FOV of 2.2°. Observations with limiting magnitude of 20.5 were carried out remotely via the Internet, in results both telescopes covered up to the 900 square degrees per night. Three main tasks were solved: developing an effective search strategy for NEAs, selecting optimal set of the equipment and creating a full complex of dedicated software. During this work more than 1,230,500 astrometric measurements of asteroids were obtained, and 1605 main belt asteroids, 17 NEAs, 8 comets, 20 Trojans of Jupiter, 4 objects from the family of Hilda, 4 Centaurs were discovered. Now we are planning to resume the asteroid survey with the new 40-cm telescope SANTEL-400/500 having FOV of 4°x5.5° which is installed in the Multa (N82, Republic of Altai, Russia). So far, the telescope is in the process of finishing and started to use for follow-up observations of NEAs.

Other direction of development of the NEAs detection is a by-product using telescopes with very large FOV (namely 20-cm with 7°x7° and 28-cm with 6°x6°) during their routine survey of Geostationary orbit. For example,

two-tubes 20-cm (FOV 7°x9°) and four-tubes 20-cm (9°x14°) telescope systems from observatories of Roscosmos [2] discover approximately one NEA per two weeks during space debris surveys on average, but the Minor Planet Center did not accept these measurements because of its low astrometric accuracy. Therefore it is important to organize a quick follow up of the discovered objects. Such experiment was arranged in 2019 that allowed to discover NEA 2019 VS4. Since ISON has organized a separate subsystem to track NEA, this work can be done on a regular basis.

ISON follow up observations: Besides of two 40-cm telescopes in Mayhill and Siding Spring, follow up observations of asteroids were carried out with the 40-cm telescopes in Hureltogoot (O75, Mongolia) and Multa, as well as with the 50-cm telescope at Andushivka (A50, Ukraine), 36-cm telescope at Kitab (186, Uzbekistan), 40-cm telescope at Uzhgorod (K99, Ukraine), and also with more larger telescopes of 0.7 - 2.6 m, which participated in the ISON cooperation with photometric observations. In the frame of ISON it was observed 1062 newly discovered NEAs, obtained 4,972 astrometric measurements which were included in 984 Minor Planet Electronic Circulars (MPEC).

In 2018-2020 the ISON follow up subsystem participated in the ESA network of follow-up telescopes. Now we are providing urgent follow up observations by requests from the Chinese Near-Earth Object Survey Telescope project (CNEOS).

ISON photometric observations: The telescopes with apertures more 60-cm are used for photometric observations of NEAs: 2.6 m ZTSh at Nauchniy (095), 2 m Zeiss-2000 at Rozhen (071) and Terskol (B18), 1 m Zeiss-1000 at Simeiz (094) and Tien-Shan (N42), 1.5 m AZT-22 and 60 cm Zeiss-600 at Maidanak (188), 80 cm OMT-800 at Mayaki (583), 70 cm AS-32 at Abastumani (119) and 70 cm AZT-8 at Chuguev (121), etc. In general, the observations are aimed at determining or clarifying the physical parameters of NEAs, such as rotation periods, sizes and elongation of the asteroids shape, surface properties and others. They are directed at study of binary asteroids and very small NEAs (less than 300 m in diameter), as well as discovering the influence of the YORP and BYORP effects on dynamics of the small bodies. With involving ISON data, the YORP effect was discovered for (1620) Geographos, (3103) Eger, and (1685) Toro [3-5]. The BYORP effect was first detected for the binary NEA (88710) 2001 SL9 also using ISON data [6]. Among the photometric tasks is the study of objects of space missions and radar observations. About 50-70 asteroids are observed annually for 200-250 nights.

In 2020, the ISON photometric observations of 60 NEAs were carried out, including more than 20 potentially hazardous NEAs. The rotation of 11 very small NEAs was studied, among which seven are new discovered asteroids. Photometry of space mission targets were done: Phaethon (planned mission DESTINY+), Didymos (planned DART and AIDA), and Ryugu (finished Hayabusa2). Lightcurve observations were performed for six NEAs to analyze of the YORP effect and for three known binary asteroids to study the BYORP effect (Ishtar, Didymos, 1991 VH).

Smaller ISON telescopes participate in observation campaigns of bright NEAs passing close to the Earth. In 2020, such campaigns were organized for observations NEAs 2020 SW in September, and for 2000 TU28 and 2020 UA in October.

Conclusion: ISON scientific cooperation obtained significant outcomes in asteroid research with small and middle-class telescopes. Trial asteroid surveys with 40-cm telescopes aimed at testing the equipment and developing the software and methods have been completed. Also attempts to use for asteroid search the telescopes of 20 ï 28 cm class are undertaken. 18 NEAs were discovered. Regular asteroid survey must start soon with 40-cm telescope SANTLEL-400/500 having FOV of 22 square deg installed in Multa (N82). ISON provides follow up from NEOCP up to 21 mag (it was observed 1062 newly discovered NEAs, results included in 984 MPEC) and carries out regular photometric observation campaigns (50-70 asteroids on 200-250 nights on average per year).

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