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Research of a solid part of interplanetary matter in the Centre of Space Research

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Abstract. The mplemented project of the Space Research Center develops into two separate projects with ITMS codes 26220120009 and 26220120029 (hereafter referred to as the first and the second phase of CKV) to date the most promising directions of research with implications for the environment and human life – research of the Sun, solar-terrestrial relations and research of a solid component of interplanetary matter in the vicinity of the Earth's orbit. In the research of interplanetary matter projects are studying physics and dynamics of small Solar System bodies, including bodies potentially dangerous for collision with the Earth, studying the dust component entering the Earth's atmosphere with rare impacts on the Earth's surface. In the first phase of CKV we are creating a station to obtain orbit data of meteors in the atmosphere. After completion of the video camera system, there will be possible to determine meteor paths in the atmosphere and calculate the orbits of particles in the Solar System before entering the Earth's atmosphere. The system will be realised at the Skalnaté Pleso Observatory. In the frame of the second phase of CKV an automatic bolide observatory will be purchased, which will be used for bolide studies at Lomnický Peak or Stará Lesná. A major modernization of the observatory for obtaining data on the solid component of interplanetary matter in particular to the Near Earth Asteroids (NEA), will be realised by construction of a robotic reflector with a primary mirror of 1.2–1.3 meters in diameter to discovering, photometry and spectroscopy of NEA. The telescope will be located in an existing robotic dome at the Skalnaté Pleso Observatory.
Key words: video cameras – automatic bolide camera – telescope

1. System of video cameras

The scientific aim is to examine the distribution of meteoroids in the solar system, looking for relationships to comets and asteroids on the one hand and various types of meteorites on the other. We will realize it by continued participation in the photographic bolide European Network with stations in 7 countries, whose results are processed at the Astronomical Institute of the Academy of Sciences of the Czech Republic at Ondřejov and also by obtaining orbits of bright photographic meteors using the double-station video cameras at a base of 40 km. Both systems have their advantages and disadvantages. A station of the European bolide network requires cooperation and the simultaneous observation at one other station at least, this disadvantage is compensated by the maximum precision of the fireball record and hence of a possible site of meteorite fall. The double-station camera video system is highly autonomous, since its operation does not require a favorable meteorological situation at the same time over much of central Europe, but it can work even when conditions are favorable only in the region. The system is easily portable and thus usable in any expedition to remote locations of the Earth with the predicted short-term increased activities of meteor showers. The system also records fainter meteors. The resulting lower precision of derived parameters is offset by a larger number of entries received. During routine system running the first station will be at the Skalnaté Pleso Observatory. The equipment is as follows:

- fish-eye objective Canon EF 2.4/15 mm $f/2.8$,
- imaging lens VIDEO OPTICON 1.9/16 mm,
- image intensifier Mullard XX1332,
- video camera Watec-120N+,
- frame grabber Pinnacle Studio Movie Board 500-PCI,
- notebook able to work outdoors,
- software *UFOCapture*, SonotaCo, Japan.

The second part of the system will be controlled remotely via the Internet and with the same equipment, as noted above, will in addition include:

- small webcam for checking of turn,
- positioned head VPT-41RSVT-PO controllable through a videoserver,
- videoserver AXIS 241S.

The UFOCapture is a software which registers and records moving objects in the night sky. It is a motion capture software that starts recording on a hard disk drive of a computer from a few seconds before the action recognized to a few seconds after the action finished. After the UFOCapture was first published in 2003, the UFOCapture V2 is now available refined by users' requests and recommendations. The software also includes an analyzer, which calculates the precise direction and elevation of meteors and the orbit of a fireball observed at more than two sites.

2. Automatic bolide camera

Multi-station photographic observations rank among fundamental in meteor astronomy as they provide the most detailed and precise information on the physical and orbital parameters of meteoroids. The successful photography and find of the Příbram meteorite in 1959 (Ceplecha, 1961) was an impetus for the establishment of the all-sky photographic cameras network for fireball monitoring and possible recovery of meteorites in Czechoslovakia. The network operating since 1963 rapidly expanded to the European Fireball Network (EN) and at the end of the 1960s it consisted of 46 stations. Parallel with the EN there were running two other fireball networks – since 1964 the Prairie Network in the USA (McCrosky and Ceplecha, 1969) and since 1971 the Meteorite Observation and Recovery Project (MORP) in western Canada (Halliday, 1973). While both the networks in the USA and Canada already stopped their operation several decades ago, the EN proceeds in the operation until present (Svoreň *et al.*, 2008). Since 2003, the Czech part of the EN has undergone a significant improvement, especially manual cameras were replaced by new full automatic cameras. The best accuracy of the orbits obtained by the EN stations at present reaches $0.03°$ in the argument of perihelion, $0.01°$ in the inclination, less than 0.0002 AU in the perihelion distance and less than $7\,\mathrm{m\,s^{-1}}$ in the geocentric velocity (Spurný *et al.*, 2007).

Astronomical Institute of the Slovak Academy of Sciences has been a part of EN since 1964. It contributed by data collected by different types of all-sky cameras located at the Skalnaté Pleso Observatory till 2007 (Porubčan *et al.*, 2009). Later, an automatic camera borrowed from the Astronomical Institute of the Academy of Sciences of Czech Republic at Ondřejov was used. A long-term partnership in research of meteors persists with the Astronomical Institute at Ondřejov. In the past, there were common observations at the Ondřejov meteor radar, in the present cooperation continues at EN, namely the joint operation of the automatic bolide station at Lomnický Peak. The test observations during three years confirmed exceptionally good conditions for the Lomnický Peak and Stará Lesná Observatory as well. That is why the purchase of camera was scheduled from the European Fund for Regional development through EU Structural Funds. The bolide network registers orbits of large meteoroids – bolides which entered the atmosphere and whose fragments could fall on the Earth's surface.

The camera placed in the High Tatras stations of the Astronomical Institute will serve to the extremely precise identification of fireball paths in the atmosphere of the Earth, and it covers most of the territory of Slovakia, southern Poland and western Ukraine. The automatic bolide camera is a product of the Czech company Space Devices. In addition to imaging the entire sky by a panoramic lens, the camera also records the total brightness of the sky and the sound record in the acoustic band at the time of a crossing fireball. The camera has a simple weather station, which before and during an exposure automatically evaluates climatic conditions. An exposure starts respectively continues only until the precipitation is not detected and the air is sufficiently clear. For assessment of the cloudiness the system is equipped with an extremely sensitive CCD camera – the result is comparing of the number of stars in the sky with a set number.

The camera can communicate via a computer network, and thus keeps control and regulate the temperature condition camera, to enter the start and end times of exposure, set thresholds for cloud detection, to obtain listings from an exposure diary and to view archived log files on the operating condition. The camera is equipped with a computer-controlled heating mantle and air heating to maintain the required operating temperature.

Short power outings are treated with a backup source of electricity, allowing the camera to return to the basic mode until the power supply is restored. Time of opening and closing the shutter is controlled by the computer, the PC's internal clock is corrected via the internet. Manual control is also possible and it is used primarily for testing.

The imaging subsystem contains a fish-eye objective Zeiss Distagon 3.5/30 mm. The system uses a plane film 9×12 cm with 32 pieces in the tray. Sharpness of images is ensured by a vacuum system that keeps the film in the focal plane. The meteor velocity is determined by a rotating sector, which rotates just above the focal plane with an optional frequency speed.

The statistics of bolide networks say that a meteorite falls into the country with a size of Slovakia, on average, once every 30 years. Observations in the testing period showed that this estimate is too conservative. For example, in 2010 at least 3 macroscopic bodies fell into the territory of Slovakia – except finding the Košice meteorite, there were 2 pieces of a few grams of meteorites in the vicinity of villages Komjatná (Fig. 2) and Topoľčianky. Given the terrain and the calculated size of the fragments, the meteorites were not found.

3. Mirror telescope for NEA observations

There is a part of astronomical research that is directly linked to the human existence and gives answers to questions of potential threat from space. In addition to research in the field of solar-terrestrial relations is mainly research of objects moving in the vicinity of the Earth. In 1973 E. F. Helin and E. M. Shoemaker began using the Palomar 0.46-m Schmidt telescope to photographic surveys focused on search for these objects. Potentially hazardous objects (PHO) are a specific class of NEA. They are defined on the basis of the size of a potential collision with the Earth, which means a distance of flyby of the Earth at less than 0.05 AU and the size of at least 150 m. It is estimated that there move around the Earth about 2100 asteroids larger than 1 kilometer and about 320 000 asteroids larger than 100 meters. It is estimated that so far there were discovered more than 7200 NEA, of which 1200 are PHO. More than 800 known NEA have a size of over 1 kilometer.

Astronomical Institute of SAS has cooperated with the Astronomical Institute of the Academy of Sciences of Czech Republic since 2003 on a Near-Earth Asteroid photometry program. The international program of searching PHOs – *Photometric Survey of Asynchronous Binary Asteroids* is a significant part of collaboration. Results of work of large author collectives have been published in the most prestigious journal in the field – Icarus. These experiences will be used for dissemination of the results of this project. In the frame of the government priorities – Security and Defense and Environmental protection, we shall solve the following questions in the Centre of Space Research:

– search for asteroids approaching the Earth, which, given their sizes would imply a local or global threat to the Earth,

– take part in observations of selected asteroids,

– participate in the calculation of the preliminary orbits for observation and improving of orbits of potentially dangerous objects,

– inform the public and the competent authorities if the risk is arisen.

To meet these objectives Astronomical Institute buys a robotic reflecting telescope with a diameter of the primary mirror of 1.2 to 1.3 meter. Its installation will be done in the existing 8-meter dome at the Skalnaté Pleso Observatory. The dome will be robotized in the frame of the project and allow us to observe by a robotic telescope remotely, for example from Stará Lesná and Košice.

There are currently several programs in the world focused on the search of NEA – Catalina, LINEAR, LONEOS, NEAT, Spacewatch. In Europe there is only one specialized search program of NEA - Italian ADAS. In this regard, the prepared telescope with a diameter of 1.2 to 1.3-m will be the largest specialized device to search for NEA in Europe and also in the world context it will play an important role. Its main contribution will be a rapid calculation of the precise trajectories in the Solar System and specify the degree of threat the Earth by individual bodies. The role a fast observation plays in, can be illustrated on the case of asteroid 2008 TC3, where between the discovery of asteroid and the impact of its fragments in the form of meteorites in the Nubian desert, passed only 20 hours (Jenniskens *et al.*, 2009).

The telescope will work in the following configuration:

– monolithic mirror aperture diameter 1.2–1.3-m,

– FoV 0.5°,

– optics from zerodur or sital material to minimize thermal expansion,

– optical system with focal ratio $f/8$,

– both Nasmyth foci equipped with field derotators,

– alt-azimuth mount,

– autoguider,

– slewing speed minimum 1.5°/sec,

– absolute pointing accuracy better than 5 arcseconds,

– conditions of operation: temperature between −20 °C and +25 °C, relative humidity between 5 % and 95 %, wind up to 15 m s^{-1}.

In the first focus a CCD camera min. 3000×3000 pixels, class 1 will be placed, in the second focus a fiber-optic spectrograph with a CCD camera, including the guiding system and the calibration unit.

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URL: SonotaCo.com, `http://sonotaco.com/e_index.html`

Figure 1. The automatic bolide camera and its summer location in Stará Lesná.

Figure 2. *Left*: An example of the videocamera for meteor observations. *Right*: A frame from the automatic bolide camera (Stará Lesná). There is catched a bright fireball from June 10, 2010. It is surmised that a small meteorite fragment (few grams only) could fall in the vicinity of village Komjatná.

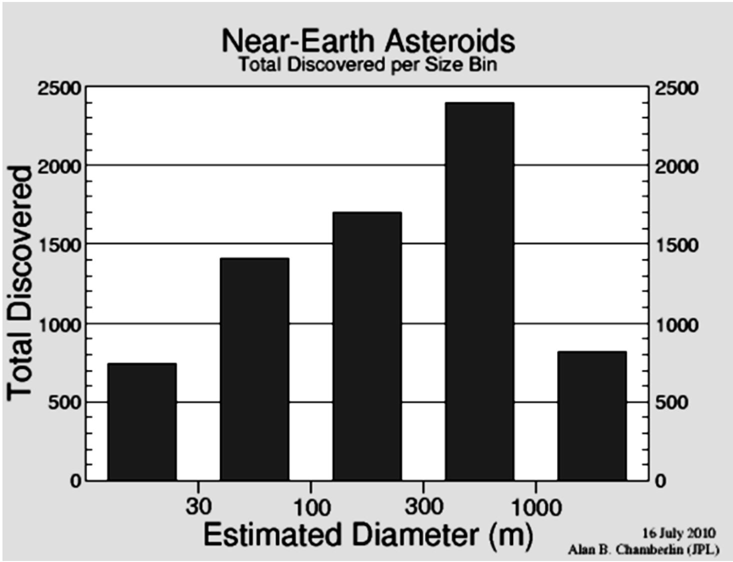

Figure 3. The chart shows the total known near-Earth asteroids per size bin. Diameters are estimated using an assumed average albedo for NEA. The first size bin represents NEAs smaller than 30 m in diameter. The second represents NEAs with diameters from 30 m to 100 m, and so on. From: `http://neo.jpl.nasa.gov/stats/`.

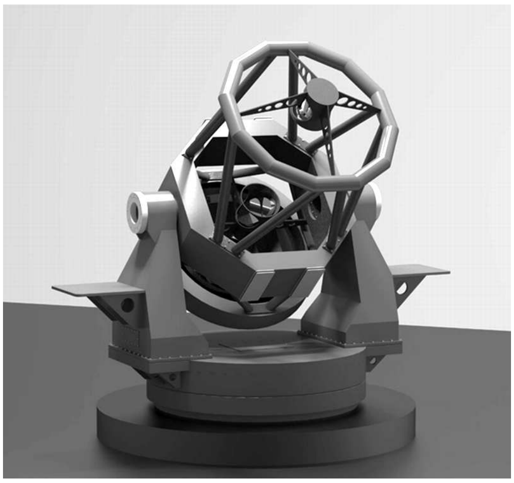

Figure 4. A model of ASTELCO telescope.