SOLAR TERRESTRIAL PHYSICS ACTIVITIES IN SLOVAKIA 1999–2000
Report to SCOSTEP

Solar-terrestrial physics (STP) activities in Slovakia continue in accord with international efforts within the STP program. The Slovak Academy of Sciences (SAS), namely, Astronomical Institute of SAS (AISAS) Tatranská Lomnica, Institute of Experimental Physics of SAS (IEPSAS) Košice, and Geophysical Institute of SAS (GPISAS) Bratislava are the main representatives of STP activities along with other institutions (Department of Geophysics of the Comenius University (DGCU), Department of Nuclear Physics of CU (DNPCU) Bratislava, Astronomical Institute CU (AICU) Bratislava, Slovak Central Observatory – Solar Section (SCOSS) Hurbanovo and Slovak Hydrometeorological Institute (SHMI) Bratislava. Below the observational activities and scientific results in 1999–2000 are reported.

Ground-Based Observations

Along with standard solar and geomagnetic observations (see both the STP Newsletter 1999 and International SCOSTEP Newsletter, v. 3, No 2, June 2000, p. 74 and Slovak National Report to IUGG 1995–1998 in *Contrib. Geoph. & Geod.*, v. 29, 1999, special issue) recent activities include:

- Total solar eclipse observations in August 1999 (Turkey and Hungary) – AISAS, SCOSS.
- The high time resolution geomagnetic observations were deployed at the Hurbanovo Geomagnetic Observatory (GO), which made it possible its participation in the international program INTERMAGNET; the Hurbanovo GO was officially included into the IMO (INTERMAGNET Observatories) network and the minute mean values of the geomagnetic components X, Y, and Z are sent to the Edinburgh GIN (Geomagnetic Information Node) on a regular basis to be included into CD-ROM data media – GPISAS.
- To guarantee the reliable Schumann resonance (SR) measurements (permanent monitoring of magnetic and electric field variations within the SR range) two experimental devices have been developed and are under test now at the Astronomical and Geophysical Observatory, CU at Modra-Piesok near Bratislava; the registration of the SR electrical component was successfully performed lately in 1999 and since the autumn 2000 it has been registered regularly – DGCU.
- The neutron monitor 8-NM-64 (in operation since 1981) data with the 1 min, 5 min and 1 hour time resolution are used for computation of the CR scintillation index which is useful in space weather forecasting – IEPSAS.
- From October 2000 the testing of the real time access to NM 1 min data runs *(http://neutronmonitor.ta3.sk)* in order to check the relationship between fast increases of dangerous energetic particle fluxes and the GLE onsets which can be used for the forecasting service for industry and satellite operation needs – IEPSAS.
- In June 1999 the observations of the Sun in Hα (1.5 Å FWHM filter) was started at the Astronomical and Geophysical Observatory Modra-Piesok – AICU.
- The observations of cloud cover over the territory of Slovakia at the Malý Javorník Observatory and processing of data from the geostationary satellite METEOSTAT in the visible, water vapour and infrared wave bands (500-900 nm – VIS-band, 5700-7100 nm – WV-band, 10500-12500 nm – IR-band) for the 30 min intervals were carried out – SHMI.

Space Experiments

Space experiments are essentially influenced by extremely limited financial funds.

- The high apogee measurements of plasma by means of the DOK2 device onboard satellites INTERBALL-1 (August 1995 – October 2000) and INTERBALL-2 (August 1996 – January 1999) and DOKS instrument onboard subsatellites Magion 4 and 5 were completed; both the detailed energy spectra and angular distribution of ions and electrons in the 20-600 keV energy range of high temporal resolution were obtained due to reliable work of the DOC-type instruments in space – IEPSAS.
- Flight of the first Slovak astronaut Ivan Bella at the space station MIR was realized on February 20–28, 1999 during the Russian-French-Slovak mission. The first Slovak space mission, STEFANIK Mission, named in honour of the outstanding Slovak astronomer, politician and French general (1880–1919), included a number of scientific experiments prepared by the SAS. Among them was the Dosimetry experiment (IEPSAS) to estimate linear energy transfer (LET) produced by cosmic rays onboard of MIR using passive track detectors – IEPSAS.
- The development and construction of new instruments for the future studies of the near-Earth plasma were continued – IEPSAS
- Development of the electronic part of SONG device for CORONAS F and preparation for the launch of the satellite (successfully launched on July 31, 2001) has required several technical changes: the works related to the tests and characteristics of particle devices, the development of testing device PPS-1 (Programmable PhotoStimulator) are in progress – IEPSAS.
- Work on two new projects have begun in cooperation with STIL Maynooth, Ireland: (a) for ROSSETTA on the ESS Processor for the data connection between Lander and orbiter, and (b) the design of Natural Atom Imager for magnetospheric plasma studies – IEPSAS.
- The experiments for monitoring the corpuscular radiation on ISS is under preparation as a joint project with Moscow State University (SPRUT and SCORPION) – IEPSAS.
- Along with plasma experiments the magnetic field measurements are intended within the ISS joint project mentioned – GPISAS.

Results of scientific investigations

Solar Physics

- A new approach to the solar corona magnetic field diagnostics was proposed using the revealed functional relation between the degree of polarization and brightness, those being measured in the coronal Fe XIV 530.3 nm emission line – AISAS.
- On the basis of the coronal green line brightness distribution analysis it has been revealed that coronal activity within the middle latitude zones of both the solar hemispheres reflects different features of the 11-year solar activity cycles – AISAS.
- It has been found that generally relevant correlation between solar corona activity and CR intensity does unexpectedly disappear during the maxima of the solar cycles, which is explained by the almost regular pronounced decrease of solar activity at the solar activity maximum of each cycle (known as the so-called Gnevyshev's gap of solar activity) – AISAS.
- Four regimes in the evolution of the coronal green line brightness considered within the 11-year solar cycles were identified and described by means of a statistical method of main components – AISAS.
- The mutual relation between evolution of both the corona shape and magnetic field topology has been revealed, which allows a new understanding of the corona flattening as a function of the solar cycle phase – AISAS.

- The course of the coronal green line brightness during the last five 11-year solar cycles was used to predict parameters of cycles 23 and 24; there are indications for an exceptionally low cycle 24 – AISAS.
- Significant correlation between solar magnetic field (MF) value (regardless of its polarity) and coronal green line intensity has been revealed (data from 1976–2000), which makes it possible to extrapolate the MF back to 1939 (time of starting of coronal green line observations); within the 1939–2000 period the MF increased at solar cycle maxima, except the current cycle 23, when both parameters studied are approximately half value, if compared with those of cycle 22 – AISAS.
- The coronal index (CI) for the 1998–1999 period was calculated and will be published soon – AISAS.
- Using the revealed relationship between CI and total solar irradiance (TSI) for the 1978–1998 period, the TSI profile was extrapolated back to 1940; the TSI increase is evident from 1940 to 1996 showing that the TSI changes are associated with local magnetic fields, to which the increased coronal green line intensity is also due – AISAS.
- The presence of the solar de Vries cycle (~205 years) during the last ice age was reported using data on cosmogenic nuclides – DNPCU.
- Considering the influence of an electron non-Maxwellian distributions (power and κ-distribution) on the electron excitation rate (EER) in the solar corona , it was shown that the deviations in EER are sufficient to affect intensities of spectral lines; the simple diagnostics of power distribution from three Fe lines was presented – AICU.
- Comparing the SOHO/EIT 195 Å and Hα images (Hvar and Modra-Piesok observatories) with the magnetic field extrapolations of MDI/SOHO magnetograms the loop structures of the July 19, 1999 flare were analyzed; a new combined extrapolation technique, which includes localized electric currents, was used to model the current-carrying flux rope; the extended helical structure was found and the pitch angle of the helical thread was determined – AICU.
- The results obtained from the investigation of the dependence of the FeXXV line intensities on the shape of the electron distribution can be used in specific applications in the solar corona, especially in diagnostics of the impulsive phase of solar flares, where the deviations from the Maxwellian distribution can be large – AICU.

Energetic particles dynamics and near-Earth plasma

- The statistical studies based on the Interball-1, 2 and Magion-4, 5 data, providing good coverage (in local time, distance from both the bow shock and magnetosheath under different interplanetary and geomagnetic activity conditions), confirmed both the Fermi acceleration mechanism at the bow shock and leakage mechanism of magnetospheric particles for the particle population in the region upstream from the bow shock – IEPSAS.
- The distribution of fluxes of ions (2-min data) on the geometry of the bow shock appears to be less pronounced with the increase of the particle energy, being clear at 20–30 keV and negligible above 200 keV; the fluxes within the magnetosheath are generally higher at higher Kp index, which confirms the magnetospheric ions to be the origin of particle population there – IEPSAS.
- High resolution spectrometric measurements by DOK2 made it possible to identify (for the first time) almost monoenergetic fluxes of ions in both the magnetosheath and region upstream of the bow shock (more than 200 events of duration from a few tens of seconds to several minutes; their mechanism is still to be explained – IEPSAS.

- The very detailed energy spectra (56 quasilogarithmically distributed energy channels in the range approximately 20–600 keV) allow to study the dispersive events both for ions and electrons – IEPSAS.
- The relation between some phenomena in the tail and in the auroral acceleration regions as well as identification of plasma regimes in the Earth magnetosphere based on magnetic field and energetic particles measurements were reported according to DOK2 data on Interball-1 – IEPSAS.
- The data from DOKS on Magion 4 along with the Interball-1, GOES-8 and 9 data were used in the study of magnetopause motion driven by interplanetary magnetic field variations. The comparative studies using also data from DOK2 on Interball-1 and 2 along with magnetic field data on the same satellites, both the plasma distribution function on satellite Geotail and ground based observations have indicated the place where dispersed ion structures are formed – IEPSAS.
- Travelling shocks between the Sun and the Earth using particle and plasma signatures recorded aboard SOHO, ACE, WIND and Interball were described – IEPSAS.
- The simultaneous study of a radar measurements, along with the plasma and flux of precipitating energetic particles measured by SPE1 device on the Active satellite passing the region above the radar site, was used to deduce fine structures of electron density and temperature – IEPSAS.
- Measurements of gamma rays by the device SONG on CORONAS-I were used for obtaining the detailed geographic maps of distribution of their flux at 500 km; the temporal variability at $L > 3$ seen in the data can be used in updating the existing trapped population models and finding the correlations with electron flux being variable during geomagnetic disturbances – IEPSAS.
- High energy protons observed by SONG instrument were used in the Forbush effect studies using the advantage of single detector scanning the variability of primary CR fluxes at various latitudes during one orbit; the comparison with ground-based neutron monitor data was done for two cases and latitudinal anisotropy was deduced from these comparisons – IEPSAS.

CR variability and cosmogenic radionuclides

- The study of the relationship between CRs and space weather events led to introducing the CR activity index from a single station, reflecting strong changes of CR anisotropy on the time scales of 1 day – IEPSAS.
- A simple wavelet method was used to determine the temporal variability of 27 and 155 day CR variability over a long time; the lack of the first periodicity was confirmed during the Gnevyshev's gap intervals; similarity of presence of the second periodicity for intervals when it is observed in interplanetary magnetic field has been revealed – IEPSAS.
- The correlation dimension of the underground muon time series was estimated using removal of the background noise by means of wavelet expansion; a periodicity of 2.53 hours was revealed over two solar cycles – IEPSAS.
- Long term periodicities in CR and in solar X-ray emissions were reported – IEPSAS, AISAS.
- The detailed computations of CR trajectories in the geomagnetic field, including both the internal and external current sources, clarified the influence of magnetospheric transparency for CR – IEPSAS.
- The computations of CR trajectories revealed the value of the effects of local time, geomagnetic activity level, the epoch and obliquely incident particles; first results indicate

the influence of residual atmosphere, especially at high latitudes; connections between neutron monitor count rate and solar modulation strength were examined – IEPSAS.
- The simulation of gamma ray production from the lunar surface and from asteroids was carried out – DNPCU.
- The simulation of particle fluxes and cosmogenic nuclides production in the Earth's atmosphere showed that these nuclides serve as a sensitive tracer of transport processes in the atmosphere and indicator of climate changes – DNPCU.
- The effects of irradiation geometry were considered in numerical simulation of *in-situ* production of cosmogenic nuclides – DNPCU.
- Using data on cosmogenic radionuclides in the GRIP ice core, the geomagnetic field between 20 and 60 Kyr BP was reconstructed – DNPCU.

Research of the Magnetosphere-Ionosphere-Atmosphere System
- The comparison of the magnetospheric response effects within the three latest solar cycles 20–22 with regard to Q and D days conditions confirms the persistence of response peculiarities for all the cycles studied – GPISAS.
- It has been shown that the AE index time series can be reconstructed on the basis of the H-component time series from other (than the AE-network) high-latitude observatories during time intervals when not all AE-network data are available – GPISAS.
- A model for the Dst index prediction was proposed using the nonlinear neural network method – GPISAS.
- On the basis of application of approaches utilizing nonlinear and multiscale analysis of time series, it was shown that a part of the sudden variations of the geomagnetic field is connected with self-organizing turbulent processes – GPISAS.
- A nonlinear approach to analyze magnetospheric disturbances shows that magnetosphere can be considered as an ideal magnetofluid in which coherent magnetic structures can arise in a wide range of spatial scales – GPISAS.
- The global singularity spectra estimation of both the "single-observatory-measure" and "multi-observatory-measure" data sets on different scales allows to separate fluctuations of either solar wind or magnetospheric origin – GPISAS.
- Using a multifractal technique, the possibility to classify geomagnetic fluctuations according to the shape of their singularity distribution functions was proposed – GPISAS.
- It was shown that on the time scale of substorms the energy dissipation in loading-unloading regime takes place in a near-multiplicative way; the influence of solar wind fluctuations present in geomagnetic response seems to be represented by deviations from the multiplicative model – GPISAS.
- The bicoloured noise model of geomagnetic fluctuations was revised and a novel multifractal model was proposed in which local scaling exponents appear to be time dependent – GPISAS.
- In order to test the hypothetical self-organized criticality (SOC) state of the magnetosphere wavelet-based filtering of intermittent geomagnetic time series was accomplished; it was argued that the magnetosphere behaves as a “near-SOC” nonlinear system – GPISAS.
- Numerical simulations (1-D photochemical model used) of the response of the middle and lower ionosphere during the very strong SPE on October 19, 1989 made it possible to obtain day time electron density profiles, which were compared with empirical ones – DGCU.
- The oscillatory character of the long-term dynamics of the main meteorological parameters (air temperature and precipitation totals) with features of 22-yr and 70–80-yr

rhythmicity is especially evident for observatories within the latitudinal belt covering middle latitudes of the globe – GPISAS.

- Utilization of the technique of the recurrence quantification analysis is likely to be a proper tool for our deeper understanding of the correspondence between geomagnetic activity level and air temperature variability – GPISAS.
- It was shown that a nonlinear descriptor calculated makes it possible to distinguish the recurrent points organized into diagonal patterns and dispersed ones; then the modulation pattern of the air temperature profile by Dst index can be clearly identified – GPISAS.

International Meetings in Slovakia

- The INTERMAGNET Meeting took place at the Hurbanovo GO on June 10–11, 2000, during which the representatives of the INTERMAGNET Executive Council and Operations Committee discussed the current issues on the real-time geomagnetic data exchange and data format unification.
- On June 12–18, 2000 the IXth IAGA Workshop on Geomagnetic Observatory Instruments, Data Acquisition and Processing was held at the Hurbanovo GO (Measurement Sessions) and in the SAS Congress centre at the Smolenice Castle (Scientific Sessions). More than 100 participants from all over the world (altogether 30 countries) took part in the meeting. The nine invited talks, 42 contributed papers, and 18 posters were presented, the majority of which was published in ***Contributions to Geophysics & Geodesy*** v. 31 (2001). This meeting was a very appropriate part of celebrating the 100-year history of the Hurbanovo GO, as David Kerridge, the IAGA President, noted.
- According to the Approval of the SCOSTEP General Meeting, June 17, 2001, Boulder (USA), Slovak National Committee of SCOSTEP is pleased to announce that the International Solar Cycle Studies Symposium will be held at Tatranská Lomnica (The High Tatra Mountains) in June 2003 (during the last week). Full information on the ISCS-2003 Symposium, which will summarize all the scientific achievements within one of the four main research programs operating under auspices of SCOSTEP during 1998–2002, can be found later in the International SCOSTEP Newsletter and elsewhere.

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