## 2. SPACE PHYSICS, GEOPHYSICS AND ASTRONOMY.

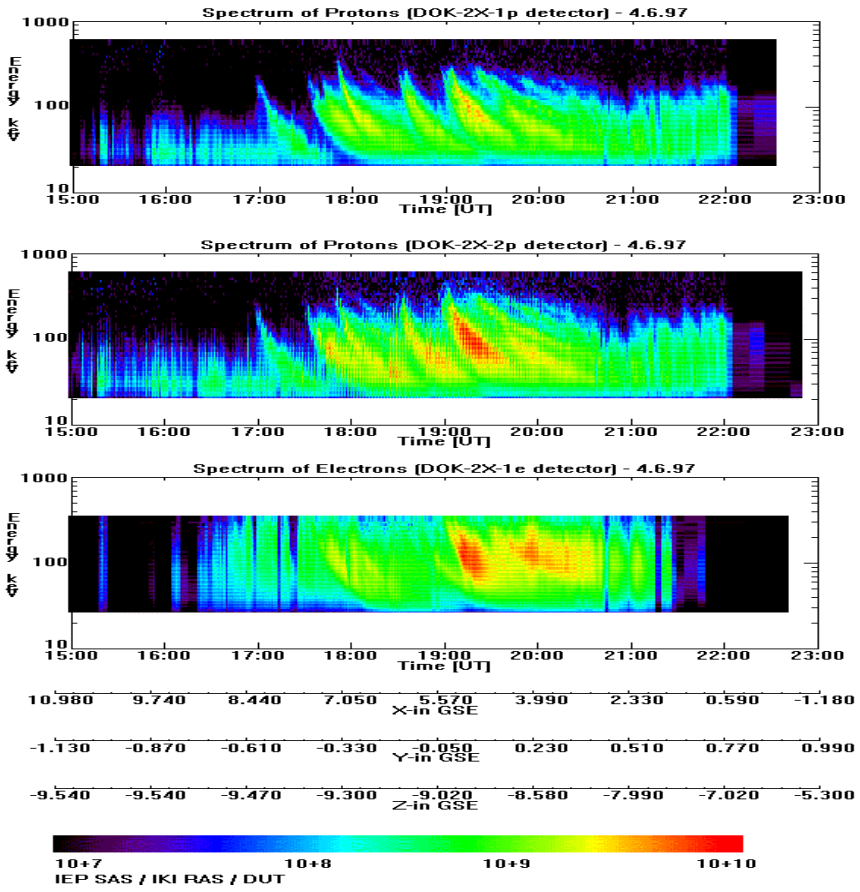
The institutes of the Slovak Republic are continuing the space research activities in the directions of space solar physics and X-ray astronomy, interplanetary matter and explorations of the comets, solar wind and its interactions with the Earth's magnetosphere, energetic particles in the magnetosphere and in interplanetary space, atmosphere and ionosphere of the Earth. The following short survey presents selected activities of the abovementioned directions and the obtained results.

Populations of particles with the energies well below those of cosmic rays and well above those of solar wind ( from few tens of keV up to several MeV) have been studied in the ***Institute of Experimenatal Physics, SAS, Košice*** in the cooperation with the laboratories in abroad. The analysis of the obtained data both from the low altitude and high apogee satellites, as well as development and construction of new instruments for the future studies have been carried out during 1997-1999. The measurements with DOK2/DOKS instruments on Interball 1 and 2, as well as on Magion-4 and 5 instruments provided large amount of data on energy spectra and angular distribution of energetic particles in the outer magnetosphere, in the geomagnetic tail, within the magnetosheath and in the region upstream of the bow shock. This required large effort in data processing and archiving . The data processing contains the separation of the frame modes (time profiles and energy spectra of electrons and protons), merging the particle flux data with the time, satellite position, IMF vector, geometry of connection to the bow shock (in the region upstream from the bow shock), orientation and pitch angles of single detectors. These works are in still in progress. For reviewing the data as well as for the multi-instrument and multi-satellite studies the review pictures are constructed. The comparison of two point measurements of energetic particles in wide energy range (Interball 1 and Magion 4) have confirmed the result found earlier in data from Prognoz-10 [1]. The statistical studies of the ion and electron flux within the magnetosheath based on Prognoz-10 and Interball 1 measurements have indicated that energy spectra of the particles close to the magnetopause are harder than those deep in that region and the strong dependence of ion flux (28 keV) in the upstream region on the angle between the magnetic field vector and normal to the bow shock at connection point exists [2,3]. The streaming of ions dawnward and duskward close to the magnetopause is not showing any clear pattern in (ZY) GSE plane. This is consistent with suggestion of patchy structure of merging at the

magnetopause and with the leakage of magnetospheric particles to magnetosheath. Possible use of DOK2 measurements for the upper limit estimate of quiet time particle fluxes in the heliosphere was examined [4]. High energy resolution (56 energy channels) of DOK2 instruments enabled to find the unusually narrow, almost monoenergetic ions within the magnetosheath and in the upstream region [5]. These measurements give also the possibility of investigating the velocity dispersive effects (one example is in Fig.8). Another results with using the DOK2 and/or DOKS energetic particle data can be found in [6-12,54-55].

Fig.8. Multiple dispersive events observed by DOK2X on the Tail probe of Interball in the outer magnetosphere. The ion detecors are oriented in the antisolar direction (1p) and at angle 62 with respect to solar direction. The different types of dispersions are seen also on electrons. The values plotted are the fluxes (in #/(cm$^2$.ster.s.keV)) multiplied by E$^3$ , where E is the kinetic energy in keV.

Low altitude measurements with use of SPE1 instrument onboard the Active (Intercosmos -

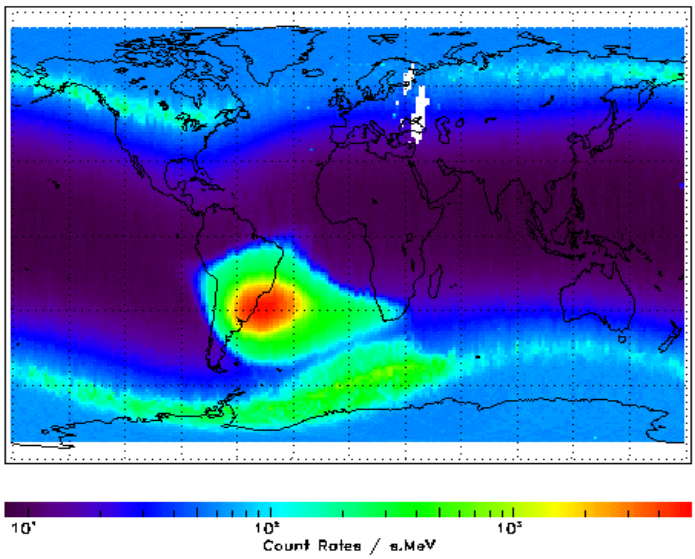



24) satellite have shown strong, short duration (few tenths of second) pulsations of electrons ( > 20 keV ) precipitating to the atmosphere. The patterns of these pulsations in subauroral and auroral regions have been described in [13-15]. Both pitch angle and energy diffusion is deduced from them. The pulsations are found in the regions with enhanced intensity of VLF emissions having also spiky character. SPE1 data are also used in the comparative study [16].

The detailed map of distribution of low energy gamma ray flux ( energy range 0.12 – 8.3 MeV ) at the altitude 500 km according to the measurements of the instrument SONG on CORONAS-I was constructed [17-19]. Another results based on SONG measurements are published in [42-44,53].

For the low altitude satellite COMPASS (checking the eventual precursors of the earthquake activity in magnetospheric data at low altitudes) the monitor of energetic particles MEP-1 [20] using the silicon detectors and highly flexible system of data recording has been developed in the international collaboration. The programmable particle spectrometer MEP-1 [21,22] was prepared for this satellite. The flight model of the MEP-1 is ready for the launch. The device is now under reconstruction for the MIR and ISS (Russian segment) purposes.

Fig.9. Map of gamma ray 3.0-8.3 MeV count rate by SONG instrument (IEP SAS in collaboration with Moscow University) on CORONAS I at altitude 500 km [17].




Also, the studies of cosmic rays were continuing in IEP SAS. The correlation dimensions of cosmic ray time series have been examined in [23,24]. Fractal properties of the time series were examined in [25]. Eventual possibilities of using cosmic ray variability as one of the parameters of prediction of Dst have been examined together with artificial neural network and fuzzy neural network schemes for the prediction [26-30,45,46]. Short term cosmic ray pulsations are analyzed in [31] and transparency of the magnetosphere for cosmic rays in [32,33]. Studies of the relations between the cosmic ray modulation and various effects of solar activity, especially the long duration effects of solar X-rays are discussed in series of papers [34-41,47-52].

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In the last two years the works of the ***Faculty of Mathematics and Physics, Comenius University, Bratislava,*** jointly with the partners in US and Switzerland were devoted to the following three areas of problem of cosmogenic nuclides:

a.The production rates of cosmogenic nuclides (CGN) in the Earth's atmosphere and in situ were studied in details. We developed numerical model for the simulation of cosmogenic nuclide production rates [8,9]. The model was used for the calculation of production rates inferred from the cosmogenic nuclide concentrations measured in GRIP samples. The dependence of CGN production rates on geomagnetic field intensity was obtained [19]. The GRIP data together with our model were used for the reconstruction of the geomagnetic field intensity in the past 200 ka. The pronounced peak observed in data at times about 40 ka B.P. was found to be due to a strong decrease in geomagnetic field intensity and is consistent even with the short change of its polarity, that is indicated also with other paleomagnetic data. The drawbacks of pyroxene application in dating based on Beryllium-10 were demonstrated in [2]. The influence of secular variations of geomagnetic field intensity on accuracy of geomorphology events dating was investigated and necessary correction factors for the last 20 ka. were determined in [3]. The model developed for the simulation of particle fluxes and CGN production rates was applied to the verification of the hypothesis claiming the strong influence of galactic cosmic rays on the global cloud cover on the Earth. Our calculations and observational data showed, that even if the cosmic rays can play some role in starting up condensation process in the atmosphere, their role is not so important as stressed by some models [22].

b. The production of gamma rays in planetary surfaces and their escape from them were also investigated. These simulations were done for the missions Mars 2001 [22]. NEAR [13], ROSETTA [10] and Lunar Prospector [5,12]. A gamma-ray detector will be flown onboard of all these missions. The measured gamma-ray fluxes will be used for the determination of chemical composition of surfaces of investigated objects. All these calculations were devoted to the study of gamma-ray production and transport dependence on chemical composition of investigated objects. In work [22] are presented results of irradiation of chunks of basalts by 2.5 and 1.6 GeV protons. The results of this experiment were used for benchmarking our models and database of gamma-ray production rates necessary for deconvolution and inversion of measured fluxes into chemical composition. For the project Lunar Prospector, we calculated the dependence of low energy neutron leakage on chemical composition of lunar surface. The dependence of neutron leakage on iron and water concentration was investigated in details, in order to compare the effects caused by higher concentration of iron

with those caused by presence of water. Our calculations showed that he effect of water is similar to the effect of iron and therefore for unambiguous determination of water presence in lunar polar regions the gamma ray data analysis is necessary [5,13]. For projects ROSETTA and NEAR were prepared databases of gamma ray fluxes calculated for various chemical compositions. Also the algorithms for the inversion of measured gamma-ray fluxes into chemical composition were developed.

c.The production of CGN in lunar surface [7] and in lunar meteorites [14] was also investigated. These simulations contributed to the determination of average galactic and solar cosmic ray fluxes during the last few million years and also to the more precise determination of the origin of these meteorites. In details was investigated also the martian meteorite Dal Al Gani 486 [16]. Its age and exposition history was determined. Using Beryllium - 10 and Nickel – 59 in the spherules from Meteor Crater, Arizona, we determined their origin and developed model for their formation during the passage of Canyon Diablo metorite through the atmosphere [4,11,17]. Production of CGN in meteorite showers and investigation of appropriate and unique shielding parameters were subjects of more studies [16,18,23,24]. As appropriate parameters were suggested the ratios of Beryllium – 10 and Aluminum – 26 in magnetic and nonmagnetic phases of meteorites. Problems with using the 22Ne/21Ne as shielding depth indicator for meteorites with radius above 30 cm were shown in paper [26].

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The ***Geophysical Institute of the Slovak Academy of Sciences in Bratislava*** was continuing the magnetospheric research. Using the satellite measurements of the solar wind parameters on an hourly basis the ring current energization was analysed for stormy periods. The relationship between the maximum depression level of storms and average energy input rate during the main phase under the sustained IMF Bs <-10 nT conditions shows the exponential dependence and reveals that along with directly driven processes the loading-unloading features of solar wind-magnetosphere interaction and their nonlinear character are of importance. Both uncorrected and corrected observational data on coronal mass ejections (CMEs) show a close relationship with occurrence of type II radio bursts and long duration (at least four hours) events LDE4 as far as both the solar cycle evolution and Carrington rotation dynamics are concerned [1]. The evolution of some solar active processes and attributed response effects within the cycle 22 was considered. The occurrence of flare-related and CME-related events was compared from the viewpoint of the medium- and long-term modulation peculiarities. The data on occurrence of not flare-related sudden ionospheric disturbances appear to be the proper CME proxy [2]. The quasi-discontinuity of the CME occurrence rate was shown to be replicated in a number of characteristics in the geospace [2].
The climate evolution within the time interval 1871--1995 covering solar cycles 12--22 based on data from the Hurbanovo meteorological station was considered in terms of variable solar

forcing. The modulation features of oscillatory character were stressed for the anomaly field of air temperature and precipitation totals [3,4].

The study of the lower ionosphere and middle atmosphere was focused on chemical composition, dynamics and appropriate solar effects using the experimental data [5]. The investigation of ionospheric dynamics is going to be started on the basis of the Schumann resonances measurements using classical methods and also a superconductive quantum magnetometer.

Nonlinear features of solar activity represented by the Wolf sunspot number and sunspot area were analysed using the concept of self-organized criticality. The existence of 60-year cycles in solar activity was confirmed . The key role of the non-gaussian distributions in understanding of the long-term periodicity of solar activity was demonstrated [6].Nonlinear study of magnetospheric MHD turbulence on the time scale of geomagnetic pulsations was performed and the usefulness of multifractal techniques was also demonstrated [7]. A synergetic scenario for Alfven field line resonances including the consideration of the energy dissipation field was offered [8]. A detailed nonlinear study of Pc3-4 type pulsations using structure functions was presented [9]. Using pulsation data from North America and Central Europe, there were compared basic features of Alfven field line resonances and upstream waves.An approach to distinguish magnetospheric and interplanetary sources of the development of pulsation activity was considered [10]. The nonlinear analysis of time series on geomagnetic data shows that mean-field and linearity ideas in modelling of the global magnetospheric activity are not adequate and the description of field fluctuations should be realized on the basis of higher-order statistics . Some highlights of history in the field of space research in Slovakia were reviewed in [11].

The extreme conditions in the magnetosphere for Q and D days in relation to solar activity level and solar plasma parameters were considered within cycles 20 and 21. The profiles of monthly means of parameters mentioned were presented within both cycles, the quiet and disturbed conditions being displayed separately. It has been shown that the solar activity index W (Wolf number) is not proper for forecasting of pronounced disturbances in the magnetosphere [12]. Some quantitative characteristics of solar, magnetospheric and ionospheric activity within the cycle 22 and especially for its phase near maximum were selected in order to distinguish the sources of sporadic activity and their response effects. Along with close interrelation between flare-related and CME-related activity some specific

features of its development on a medium- and long-term scale are reported which can be of interest for space weather
prediction [1].
The consideration of the anomaly field profiles calculated for air temperature and precipitation totals data series of more than 100 years long reveals the oscillatory character of their long-term dynamics with 3-5-yr, 22-yr and 70-80-yr rhythmicity. Solar forcing and, in general, space weather dynamics appears to be relevant to the climate evolution which is confirmed by data not only from the Hurbanovo meteorological station [13,14], but also from a number of stations located in the latitudinal and longitudinal strips crossing Central Europe [15,16].

Model calculations, using the lower ionosphere model for reflection heights of 162 kHz radio waves, were carried out and compared with experimental heights. Model-experiment differences in seasonal variation of these heights is due to seasonal variation of the NO component predominantly. The maxima of reflection height occurring in equinoxes are likely to reflect the global change in atmospheric circulation during which the transport of NO from above downward is interrupted [17].
On the basis of the analysis of a 100 year record of monthly means of the geomagnetic field vertical component measured at the Niemegk observatory, the nature of MHD turbulence within the earth's fluid metallic core was investigated. It was shown that for a subset of singularity exponents, the energy transfer rate between scales is intermittent and non-homogeneous, this being in agreement with the predictions of the simple multifractal p-model [18]. Using the concept of the Extended Self Similarity (ESS) we analysed the X-component time series of geomagnetic field fluctuations. ESS does not allow to make an unambiguous statement about the non-triviality of scaling laws in "geomagnetic" turbulence, however, higher order statistical moments represent appropriate diagnostic tools for mapping the contributions of various remote magnetospheric sources to local observatory data. In fact, plotting n-th order structure functions against the fourth order structure function we showed that low-frequency geomagnetic fluctuations up to the order n=10 follow the same scaling laws as MHD fluctuations in the solar wind, however, for higher frequencies a clear departure from the expected universality is observed for n>6 [19]. On the basis of the analysis of multifractal phase transitions it was shown that the magnetosphere dynamics ehibits self-organized critical behaviour. This notion opens a way for the analysis of globally coherent behaviour of magnetospheric fluctuations[20]. Important statistical information on

nonhomogeneous energy transfer rate inside the magnetosphere system was obtained using the method of the large deviation multifractal spectrum. It was shown that the multifractal probability measure constructed from geomagnetic time series is singular and its support is a fractal [21]. On the basis of cross power spectral density analysis of geomagnetic pulsation data from station pairs in Central Europe and North America field line resonances were identified. Pulsations having zero spatial gradients were also identified and may be derived from solar wind upstream waves[22].

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The activities of the ***Astronomical Institute of the Slovak Academy of Sciences, Stará Lesná***, in the program COSPAR devoted to the probelms of solar and stellar physics are ever more used satellite measurements, mainly in the UV, XUV and X-rays. It concerns mainly the satellites YOH-KOH, SOHO, TRACE and from previous ones NIMBUS 7, NOAA series, GOES series and the stellar IUE. By comparison of ground-based and space measurements we try to extend the satellite measurement series further to the past. Comparing the distribution of the intensity in the emission line 530.3 nm (the measurements from Lomnický Štít), intensity in the continuum (the measurements using the Mark III coronagraph at Mauna Loa, but processed by software made by us) and in the X-rays (measurements from satellites Yoh-Koh and GOES) we came to the conclusion, that processes of ionisation, so the maximal

radiation in lines as well, are concentrated in the regions of maximal gradient of the course of continual radiation and not in the regions of maximal electron density. Confirmation of this conclusion will lead to a revision of the theory of excitation of coronal ions. According to methods developed earlier we estimated from own observations and those made worldwide the coronal index of solar activity for years 1996-1998 and completed the catalouge of prominence for the same period. Analysing the all data (1939 - 1998) we realised some regularities in the course of the cycle of solar activity in the corona. [1-5]. Coordinated ground-based observation of the solar photosphere together with observations onboard the SOHO was carried out as well [4]. Results of these studies are used in searching connections between the solar activity and the geomagnetic disturbancies. [6]. For the analysis of the symbiotic star CH Cygni were used observations from the satellite IUE (ESA, NASA), [7].
The dynamical processes in solar corona were studied [8]. The North-South symmetry in the green corona was reported [9]. The coronal shape changes during the solar cycle were considered [10] and a new database of the green-line corona brightness was compiled for the five solar cycles [11]. Other papers relevant for COSPAR are listed in [12-44].

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