Chapter 6

DEPARTMENT OF SPACE PHYSICS

6.1 STAFF

6.1.1 Scientific staff

Anna Antalová, Ján Baláž, Ladislav Just, Karel Kudela, Marián Slivka

6.1.2 PhD students

Pavol Bobik (PF UPJS), Radoslav Bučík (TU Zvolen). Their PhD theses are lead by DSP.

6.1.3 Technical staff

Vladimír Kollár, Igor Strhársky, Ronald Langer, Jana Štetiarová, Samuel Štefánik, Viera Štrbinová, Anna Tomičová

6.2 SCIENTIFIC ACTIVITY

6.2.1 Introduction

Department of Space Physics (DSP) is one of the oldest departments of the Institute. The research is oriented to the experimental study of energetic particles in space based on measurements from the satellites (1) as well as of cosmic rays measured with the ground based instruments (2). Both types of studies are devoted mainly to the obtaining relevant informations on the physical processes within the magnetosphere of the Earth in the heliosphere. In addition, heavy nuclei interactions are studied too.

6.2.2 Projects

Project of Slovak Scientific Agency VEGA

G–1353 Sounding of the magnetosphere by energetic particles (1995-1997)

G–5137 Energetic Particles in Space: Dynamics of Magnetospheric and Heliospheric Fluxes (starting from 1998)
Principal investigator: K. Kudela

The staff is participating also in other projects of VEGA lead by other institutions.

6.3 RESULTS

6.3.1 Cosmic Ray Dynamics at Neutron Monitor Energies and above.

Neutron monitor at Lomnicky stit is providing continual measurements of secondary nucleon component. The data collection, barometric pressure correction, archiving, continuous "in situ" checking of the measurements and upgrading the electronics is routinely done by the group of technicians in High Tatras (V.Kollár, R. Langer, S.Štefánik and recently also by I. Strhársky). The data are produced with 1 minute resolution. High count rate, related to the unique measurement place (2634 m altitude) is allowing to perform studies of the cosmic ray variability of small amplitudes. The review graphs of 1 month measurements together with the geomagnetic activity indices and interplanetary magnetic field are prepared by P.Bobik. The studies of solar ground level events, as well as long term cosmic ray investigations, are based on existing measurements. Recently a new registration electronic system for neutron supermonitor located on Lomnicky stit observatory have been designed by I. Strhársky and colleagues. Finalization is in progress.

Cosmic ray data, obtained from numerous stations on the ground of the Earth and from underground measurements (higher energies), including in particular also those of neutron monitor at Lomnicky stit, provide a large data set for examining the properties of cosmic ray time series at various primary rigidities and covering periods corresponding to different solar activity levels. The rapporteur talk [1] summarized the recent progress and present knowledge of the selected items of quasiperiodic variations of cosmic rays and of energetic particle research relevant to the studies of terrestrial environment.

In addition to the fractal dimension estimates of cosmic ray time series we described in the preceeding period, the correlation dimension of the time series of primaries about 145 GV rigidity was obtained jointly with the group of Shinshu University Cosmic Ray Group recently [2]. The influence of the diurnal variation [4] and high level white noise to the signal [3] was checked, in the same collaboration. The first experience with the description of cosmic ray time series based on wavelet transform, was obtained. The application of the method on the long term, stable measurement (Misato, Japan, underground muon telescope, 1975-1994) has shown the different behaviour of the small scale temporal variability (2 hours) and larger one (> 16 hours) if compared with the solar activity level.

The relevance of cosmic ray time series for eventual prediction of the nonstationary physical processes with impact of near Earth surrounding has been checked with using Lomnicky stit data [5,6]. Statistical type of studies performed here is accomplishing the single effect detailed analysis illustrating the increase of variability on a single neutron monitor before the disturbance as a consequence of increasing the cosmic ray anisotropy (Bieber and Evenson, GRL, 25, p.2955-2958, 1998). Thus it is reasonable to check the possibility of using the cosmic ray time series as one of the parameters of ANN (artificial neural network) and/or FNN (fuzzy neural network) for predictions of geomagnetic storms. Such approaches were used in the collaboration with PF UPJS recently on the data sets describing the plasma and magnetic field structures near the Earth [7,8,9].

It was found that the short term periodic variations of secondary cosmic rays in the Brazil magnetic anomaly region, observed by a series of balloons in that region, may be caused by the pulsating character of "screening" of primaries by the magnetosphere [10]. In addition to the periodic variation of the altitude of mirror points of trapped radiation suggested earlier as an explantion for the observed secondary variations, the variability of transparency of magnetosphere provides another possibility. Indeed the periodicities are observed also in Lomnicky stit NM measurements.

The structure of forbidden and allowed rigidities for Lomnicky stit and Rome stations has been computed for various levels of geomagnetic activity decribed by the Kp index and using the combined IGRF (internal) and Tsyganenko 89 (external) model of the field. While the seasonal cosmic ray variation is not significant at these positions, the amplitude of the diurnal variation for the quiet time and most disturbed one (Kp > 6) is differing by few tenths up to one per cent, assuming also the response (yield) function and the effect of the atmosphere [11,12].

Soft X-ray parameters, derived from Solar Radiation satellite measurements, were used to analyse, on daily basis, their relationship with galactic cosmic ray (GCR) modulation and geomagnetic storms. Coronal Mass Ejections (CMEs) are a principal heliospherical phenomenon, which implies a cause-effect relationship between the interplanetary shocks responsible for GCR-modulation as well as geomagnetic storms. The main difficulty in investigating the solar origin of the nonrecurrent heliospherical shocks arises from the fact that the plasma clouds ejected by the Sun are, in general, observable with the coronographs only when they occur near the limb of the Sun. Thus, the detection of CMEs on the disk must rely on some proxy parameter. One of the most convenient appears to be the intensity of the solar soft X-ray flare emission, and in particular those called Long Duration Events (LDEs).The analysis of soft X-ray data yields the following results: We investigate [13] the role of the coronal mass ejections (by using soft X-ray solar emission as proxy data) in producing the nonrecurrent geomagnetic storms in the period 1969-1974. The linkage between these phenomena is confirmed however, in turns out that CMEs associated with chromospheric flares, accompanied by type IV radio emission, are the most effective in perturbing the geomagnetic field. From the multivariate daily sequence analyses of GCR/Solar X-Ray Parameters [14] it was found that extreme values of the cross-correlation functions (on daily basis) remain less than 0.5. The periods in which these values are significant correspond to the ones in which large-scale activity phenomena occur on the Sun (in 1970.5-1971.5 and 1972 years). We examine the short-term variability of GCR records, from two neutron monitors with different cut–off rigidities, namely Calgary (CA) and Lomnicky stit in 1968–1996 years. As for the LDE flare index, the new consecutive daily sequences were calculated on the daily basis [15-18]. The autocorrelation analysis [19] of the SXR solar parameters (XBG and LDE) clearly shows, that the behavior of the medium-term X-corona (i.e. within a 27-day synodic solar rotation) depends on the solar cycle phase. Instead, on a short-term scale (1 day) this dependence exists only for the X-flaring corona, with the X-background nearly stable from the maximum to the minimum activity phases.

collected by K. Kudela and A. Antalová

6.3.2 Medium Energy particles within the Magnetosphere and near its Boundaries.

Populations of particles with the energies well below that of cosmic rays and well above the solar wind (from few tens of keV up to several MeV) are systematically studied by the DSP in last few years. The analysis of the obtained data from both low altitude and high apogee satellites, as well as development and construction of new instruments for the future studies have been carried out during last two years.

The Interball project was realized by launch of two satellites (Interball-1, Interball-2) and two corresponding subsatellites (Magion 4 and Magion 5) in 1995 and 1996, respectively. The measurements with DOK2/DOKS 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. The amount of the data (for Interball-1 now more than three years partly covered by DOK2, [33,34]) required large effort in data processing and archiving (done especially by M.Slivka and J. Štetiarová). The data processing contains the separation of the frame modes (time profiles and energy spectra of electrons and protons), and merging the particle flux data with the time, satellite position, IMF vector, geometry of connection to the bow shock (in the region upstream of the bow shock), orientation and pitch angles of single detectors. These works are 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 by us earlier on the data from Prognoz-10 [26]. 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 [43]. 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. The fluxes of energetic ions at Interball 1 upstream from the bow shock for the positions of the satellite not connected to the bow shock along the field line (simplified assumption of the field line as a straight line) are providing the upper limit to the quiet time fluxes in the heliosphere studied in detail [27]. Several particular results have been presented at the NATO Advances Research Workshop "Coordinated Studies of the Solar Wind-Magnetosphere-Ionosphere Interaction: Interball observations" held in Kosice, September 7 - 11, 1998. The abstracts of 7 papers with our coauthorship are in the abstract booklet.

Low altitude measurements with use of SPE1 instrument onboard the Active satellite have shown strong, short duration (few tenths of second) pulsations of electrons precipitating to the atmosphere. The patterns of these pulsations in subauroral and auroral regions have been described in [22,24,25]. 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.

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 [31] using the silicon detectors and highly flexible system of data recording has been developed in the cooperation with IEP RAS Moscow and UNICAMP Campinas. The technical group of the DSP developed and finalized programmable particle spectrometer MEP-1 [28,29] for this satellite. The flight model of the MEP-1 is ready for the launch.

Some theoretical and practical methods and tools were developed for system identification of particle registration devices (geometrical factor, 3D-anisotropy) and for study of system dynamic behaviour by programmable stochastic photostimulation [30].

The distribution of gamma ray flux based on the whole set of available data from CORONAS-I (experiment SONG) was obtained in geographic coordinates showing the strong increase in the brazil magnetic anomaly region [32].

collected by K. Kudela, M. Slivka and J.Baláž

6.3.3 Fragmentation of Relativistic Nuclei in Nuclear Emulsion

The knowledge of fragmentation parameters in nuclear collisions is important in particular for the understanding of the composition of cosmic rays in its sources, for the transport as well as for studies of galactic cosmic ray exposure behind the shielding in space flights. Recently the interactions of ^{84}Kr at energy 0.95 GeV/nucl. with nuclear photoemulsion have been studied. The bounce-off effect of primary nuclei fragments were confirmed using the azimuthal correlation function method. The magnitude of this effect depends on the impact parameter of interacting nuclei. This effect is independent on the magnitude of primary energy in the region up to 2 GeV/nucl. [35,41].

The angular distribution of projectile-associated He fragment from Pb induced reactions on stationary Pb target at 158 A GeV/c has been studied. Two emission components are appearing in the projected angular spectra of the He particles [36]. The charge distribution of relativistic nuclei fragmenting (with Z> 2) of ^{197}Au nuclei at 10.7 GeV/nucl. has been measured. With the help of moments of these distributions research, we found out the asymptotic behavior of fragmentation's parameters for the peripherical collisions of ^{197}Au nuclei in emulsion. [39].

With the help of transverse-momentum of relativistic fragments of primary nuclei study where registrated collisions with Ag(Br) nuclei at energy 10.7 GeV/nuc. Its correlation with the emission of target nuclei fragmet were studied too [40]. We observed found out large cross section for fission Au+Emul. in comparison with published. After this analysis could calculate the fission yields of Au nuclei on different nuclear targets. The fission yield for Au+H is Y_H=0.041±0.025, in agreement with the value obtained from the p+Au in wide range energies. For the interactions on the CNO group we obtained Y_{CNO}=0.026±0.018 and for AgBr $Y_{AgBr}=(5.14\pm2.6)*10^{-3}$. [42] The results obtained in the EMU01 collaboration include the coauthors from Armenia, Australia, China, Germany, India, Kazakhstan, Russia, Slovakia, Sweden, USA, Uzbekistan.

collected by L. Just

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6.5 OTHER ACTIVITIES

The results described shortly in part 6.3 have been obtained in wide international collaboration which is completely listed in corresponding paragraph of the recent biennal report (domestic laboratories and those in the Czech Republic, Italy, Russia, Sweden, Switzerland, USA, Germany, Japan, Brazil, Finland, Greece and other countries).

6.5.1 Organization of scientific conferences

The most important activity of the interantional character was the NATO Advanced Research Workshop " Coordinated Studies of the Solar Wind - Magnetosphere - Ionosphere Interaction: Interball observations" organized in Košice, September 7 - 11, 1998. The director and co-director of the event were Dr. D. G. Sibeck, Johns Hopkins University, Applied Physics Laboratory, Laurel, MD, USA and K. Kudela, respectively.