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Interactive DataBase of Cosmic Ray Anisotropy (DB A10)

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Abstract: The worldwide neutron monitor (NM) network is a unique instrument for obtaining with high accuracy information on density variations, energy spectrum and anisotropy of Comic Rays (CR) at the Earth orbit, outside its atmosphere and magnetosphere. We obtained these hourly average parameters for the whole period of the CR monitoring by the NM network (from 1957 till present). This huge amount of data is combined within the MySQL database. We have developed the Internet-project for supplying of Comic Rays Anisotropy data in different digital and graphical forms.

Introduction

In the energy rage of 1 - 100 GeV the CR intensity is nearly isotropic. A level of the anisotropy is arbitrary less than 1%. However not other CR characteristic may provide so much information on conditions in the interplanetary space as do the CR anisotropy. A shape, direction, value and energy spectrum of the anisotropy are associated with definite structures in the heliosphere, namely, with strength and direction of the Interplanetary Magnetic Field (IMF) and level of its irregularity as well as Solar Wind (SW) velocity. The CR anisotropy observed at the Earth reflect structural characteristics and processes in the solar wind within wide spatial (10^9 -10^{14} cm) and temporal (10^3 – 10^8 s) ranges. These characteristics and processes can be obtained from the anisotropy measurements. A behavior of CR anisotropy and gradients is tightly connected with a position of the heliospheric current sheet and high speed SW. Therefore, all main structural SW characteristics and their dynamics are reflected in a behavior of CR anisotropy and data of ground based observations of the anisotropy might be considered as a reliable tool for interplanetary space diagnostics.

Method of anisotropy selection

Several methods for selection of CR anisotropy from data of ground based observations have been elaborated. [1-4]. Using only the zero and first harmonics an expected variations for a observational point ***i*** in a time moment ***t*** can be written:

$$\delta^i(t) = aC_0^i(\gamma) + (x \quad y \quad z)\cdot\begin{pmatrix} Cos(t) & -Sin(t) & 0 \\ Sin(t) & Cos(t) & 0 \\ 0 & 0 & 1 \end{pmatrix}\cdot\begin{pmatrix} C_x^i & C_y^i & C_z^i \end{pmatrix} + \ldots, \quad (1)$$

where $C_0^i(\gamma)$ and C_x^i, C_y^i, C_z^i are acceptance coefficients between variations outside the magnetosphere and variations observed at the ground. These coefficients depend on coordinates and altitude of the observational point and are calculated for each station. Acceptance coefficients for the zero harmonic are determined relatively simply:

$$C_0^i(\gamma) = \int_{Rc}^{\infty} R^{-\gamma} W^i(R_c, h, R)\, dR \quad (2)$$

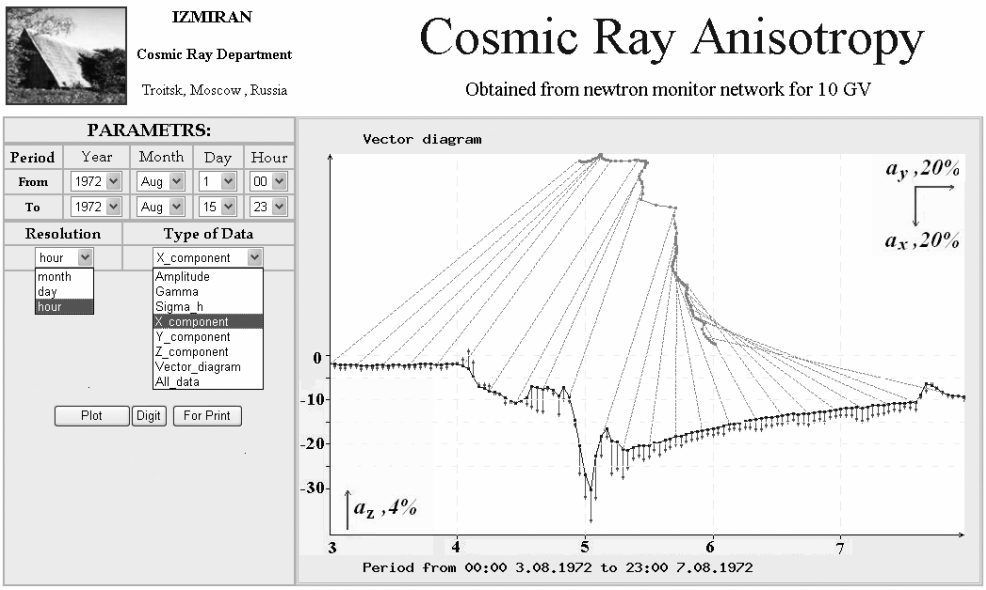

Figure 1: The Internet project "Anisotropy of Cosmic Ray"
http://cr20.izmiran.ru/AnisotropyCR/Index.php

where $W^i(R_c,h,R)$ is the coupling function of primary and secondary variations, $aR^{-\gamma}$ - a spectrum of zero harmonic variations with a power coefficient - γ. A calculation of acceptance coefficients of the first harmonic is very complicated, it is necessary accounting not only the Earth atmosphere, using the coupling function $W^i(R_c,h,R)$, but also CR interaction with the magnetosphere. Such calculations were per
formed for the NM network in [5]. The matrix in (1) determines a connection between solar and geographical coordinate systems accounting a corresponding turn of the last for each time moment t. A solution of the reverse problem, i.e. a solution for (1) relatively a,γ,x,y,z using the first harmonic approach, determines a density a, its spectral characteristic γ and a vector of CR anisotropy (x,y,z) near the Earth orbit outside the magnetosphere and the atmosphere.

We calculated hourly average values of such parameters using the Global Spectrographic Method (GSM) from data of 60 NM's for the whole history of CR monitoring from 1957 till present. A large number of used stations provides as a very good accuracy of obtained characteristics well as absolutely continuous data set of CR anisotropy for each hour of the considered period. Since this method is relatively complex it is important to provide a free public access to these data. For solving many problems of solar-terrestrial physics one needs knowing CR variations behind the magnetosphere but not using data of some particular station, possibly very good and stably working, containing atmospheric and magnetospheric effects.

General description of the DataBase

The calculations are collected in the MySQL data base of Cosmic Ray anisotropy. A chosen format of data storage allows a free access to the data as from the local computer network well as from the Internet. A usage of the MySQL data base allows a possibility arranging requests of different structure, improves variants of data usage and representation and provides a possibility of data exchange with external systems and databases of other projects. The Internet project for supplying of Cosmic Ray anisotropy data in different formats to a final user (http://cr20.izmiran.ru/AnisotropyCR/Index.php) was created applying a widely and successfully realized combination of the script-language Php with the MySQL database. A usage of the Php and MySQL pair provide operability and rapidity of data access even from

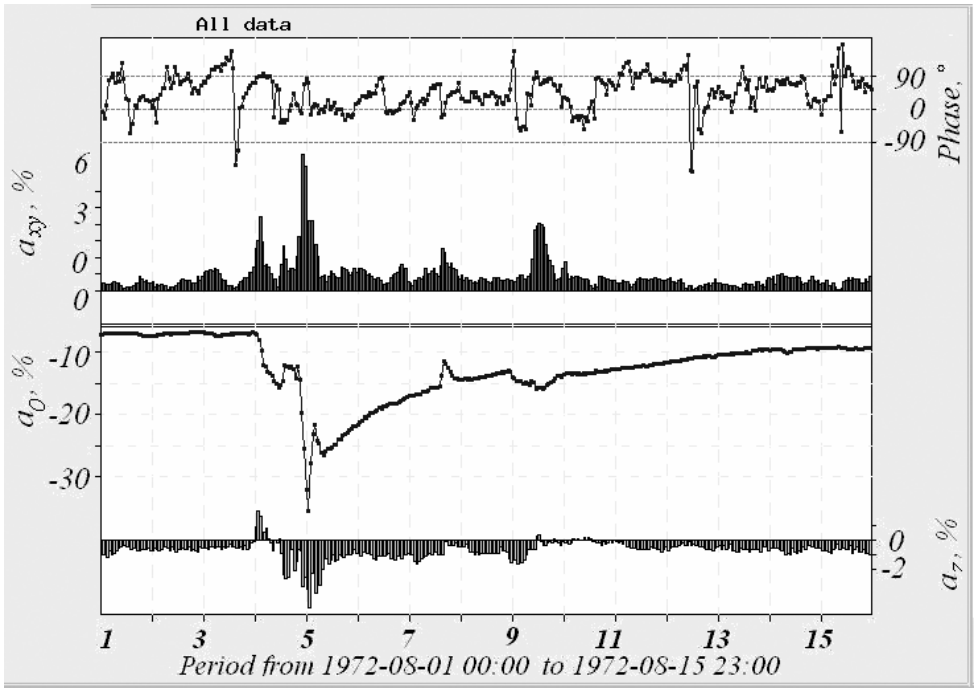

Figure 2: Behavior of all characteristics of CR Anisotropy in a graphical form

the Internet, because requests and their further operations are performed at the project server.

The database includes hourly average values of CR density a, its spectral characteristic γ and (x, y, z) components of anisotropy vector obtained by the GSM using data of the NM network from 1957 till present. Procedures for uploading of the database are ready, so in the nearest future it would be possible data publishing in real time. In the considered model for calculations of CR parameters we do not account an impact of the second and higher harmonics. For estimates of their possible impact a mean square deviation of experimental data from the accepted model was calculated by data of high latitude station for the whole period.

The internet project publish data of CR density and (x, y, z) anisotropy vector components in graphical and digit formats. Besides, for any chosen period it is possible to generate a diagram of connected vectors in the equatorial plane. Figure 1, which shows a vector of North-South anisotropy with a curve of density values, illustrates such a diagram. There is a possibility for any arbitrary period to get a simultaneous behavior of all characteristics of CR Anisotropy in a graphical form as illustrated in Figure 2 shows a temporal dependence of anisotropy vector amplitude in the equatorial plane **x+y (Axy)**, its phase, density variation A0 and North-South anisotropy. Data in graphical and digit formats can be obtained upon the request for any time interval with hourly, daily and monthly averaging. Variations of all characteristics are displayed relatively the base period of 1976.

A number of accounts in the database is 450000, capacity 600 MB. Monthly updating, updating in real time is possible. Free access, the address http://cr20.izmiran.ru/AnisotropyCR/Index.php

Usage of DB A10 for pure scientific and applied problems

Database of CR anisotropy can be used for two types of problems. Firstly, this is an investigation of structural characteristics of SW and they dynamics, calculations of CR gradients, searching for correlations between parameters of the interplanetary medium and characteristics of CR variations [6-9]. Secondly, this is applied problems, for instance, a forecast of geomagnetic storms.

Besides, in some cases it is necessary to exclude CR variations from observations, for instance, during the latitudinal survey or estimates of water equivalent of snow cover thickness [10]. With this goal the Internet project, which allows getting the expected variations (within the model (1) for annoy period beginning from 1957) in interactive regime for any point on the globe with given coordinates based on DB A10 data, is developing. These data are also important for a more accurate determination of barometric coefficient of all available NM.

Conclusions

The interactive database described might be used for solving as pure scientific well as applied problems. The MySQL database for storage CR anisotropy data (10GV) and the user interface allow arranging requests of different structure, data coupling with external systems and databases, using in other projects.

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