PECULIARITIES OF THE 23-th SOLAR CYCLE ACCORDING TO COSMOGENIC RADIONUCLIDES IN THE TAMDAKHT AND ASH CREEK CHONDRITES.

V. D. Gorin, V. A. Alexeev, and G. K Ustinova. Vernadsky Institute of Geochemistry and Analytical Chemistry, RAS, Moscow V-334, 119991 Russia; E-mail: aval37@chgnet.ru

Processes on the Sun and solar activity notably affect processes in heliosphere through generating and perturbing heliosheric magnetic fields. On the greatest scale, this is pronounced as the solar modulation of the galactic cosmic rays (GCR), i.e., changes in the GCR intensity at various heliocentric distances and heliolatitudes, according to various levels of solar activity. Obviously, the GCR intensity thereby provides a finely tuned tool for studying the electromagnetic structure of the heliosphere and its changes at variations in solar activity. Such studies require, however, long sequences (covering several 11-year solar cycles) of homogeneous data on the GCR intensity in interplanetary space.

Cosmogenic radionuclides with different $T_{1/2}$, which are observed in meteorites, are natural detectors of cosmic rays along the meteorite orbits during ~1.5 $T_{1/2}$ of the radionuclides before the meteorite fall onto the Earth. The investigation of radionuclides with different $T_{1/2}$ in the chondrites with various dates of fall, which have various extention and inclination of orbits, provides us with such long sequences of homogeneous data on the intensity and variation of GCR of E >100 MeV in the 3D heliosphere [1]. Nowadays, such a sequence of certain homogeneous data on the GCR intensity and gradients in the inner heliosphere (at 2–4 AU from the Sun) covers ~5 solar cycles [2]. The continuation of this sequence to 2009 was made possible by determining concentrations of radionuclides in the fresh-fallen Tamdakht and Ash Creek chondrites [3].

The obtained data on the radionuclide contents in these chondrites are presented in Table 1 [4] , and our monitoring of distribution and variations of the radial gradients of GCRs in 1954-2009, according to the results of successive study of radionuclides in the fresh-fallen chondrites, is demonstrated in Fig.1 (the last three points on the right are from the data on cosmogenic radionuclides in the Tamdakht and Ash Creek chondrites; regarding the other data see [2]). It can be readily seen that GCR gradients along the meteorite orbits (within 2–4 AU from the Sun) strongly depend on the solar cycle phase and vary from low and even negative values during the years of the minimum solar activity to ≥80–100%/AU during the years of its maximum. The average gradients during modern solar cycles (~20–30%/AU) are the same as the gradients over the last one million years, which testifies to the fact that the mechanism of solar modulation of GCR does not change, at least over the last ~1 Ma.

The Tamdakht and Ash Creek chondrites fell during the years of minimum solar activity between the solar cycles 23 and 24. This time period proved to be very unusual [5,6]. The minimum of cycle 23 was expected in 2008 [7]. However, solar bursts in March of 2008, which should have indicated the onset of solar cycle 24, had the polarity being typical for bursts in the solar cycle 23, so that the solar cycle 24 was predicted to begin approximately in 2012 [8]. Thus, the extended solar cycle 23 continues a sequence of cycles (at least six of twenty_three), being longer than twelve years [6]. Our data on low GCR gradients during approximately four years before the falls of the Tamdakht and Ash Creek chondrites onto the Earth, derived from the ^{22}Na concentrations, are typical for solar activity minima (Fig. 1). On the contrary, the high GCR gradients during approximately fifteen months before the chondrite falls (as deduced from the ^{54}Mn concentrations) are, on the one hand, typical for the ascending branch of solar cycles, if the solar cycle 24 did start to develop. At the same time, these gradients could result from significant latitudinal components of the GCR gradients, which are just typical for the solar activity minima.

Table 1. *The content of cosmogenic radionuclides (in dpm/kg) at the moment of fall of the Tamdakht and Ash Creek chondrites [4]*

Chondrite	^{46}Sc	^{54}Mn	^{60}Co	^{22}Na	^{26}Al
Tamdakht H5	-	200 ± 20	16 ± 3	90 ± 10	55 ± 6
Ash Creek 6	25 ± 5	180 ± 20	41 ± 5	95 ± 10	66 ± 7

The presence of latitudinal GCR gradients in the heliosphere indicates that the modulation region is not spherical, and provides support to the hypothesis of its meridional compression, first of all, at latitudes of ±40°, with the maximum gradient values at heliolatitudes of ±(15–20)° [1]. These gradients were discovered at the minimum of solar cycle 20 in 1975–1976, basing on the data of the radioactivity of the Dhajala and Innisfree chondrites, whose orbits are known [1], and they are now reliably measured during the Ulysses mission in 1996–2009 (see [7], and others in that book). If the minimum of the solar cycle 23 has not terminated so far, it could be supposed that the orbits of the Tamdakht and Ash Creek chondrites [9] have an inclination $i > 0$. A high probability of the latter scenario also follows from the fact that the GCR intensity during that period of time was the highest during the latest five cycles of solar activity, and, starting in 2008, it increased mostly due to particles with the energy being less than a few GeV [10]. This testifies to the weakness of heliospheric magnetic fields, which was typical for this unusual time span [11]. Hopefully, the orbits of these chondrites, calculated according to the observed radiants of their falls, will facilitate the unambiguous resolution of this problem.

The results of study of cosmogenic radionuclides in the Tamdakht and Ash Creek chondrites and the cosmophysical information derived from these data are the important links of the performed monitoring of processes conditioned by the solar activity in the 3D heliosphere.

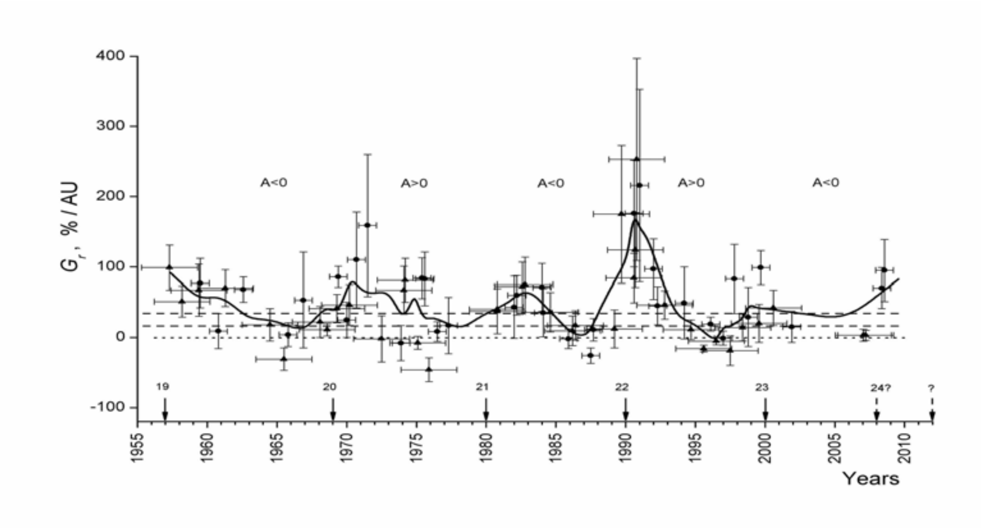

***Fig.1** – Monitoring of distributions and variations of the integral radial gradients G_r of the galactic cosmic rays of the energy $E > 100$ MeV in 1954-2009 along the orbits of the fresh-fallen chondrites (the curve is the result of smoothing of the input data over five points)*

References

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