*"Physics of Auroral Phenomena", Proc. XXV Annual Seminar, Apatity, pp.157-160, 2002*

Polar Geophysical Institute

# HEART RATE VARIABILITY PARAMETERS VARIATIONS AT GEOMAGNETIC DISTURBANCES IN ARCTIC AND ANTARCTIC REGIONS

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**Abstract.** The existence of the Heliogeophysical activity impact on the human health is well known now (See for example (1-3) and references in there) but many results in this field were obtained on the basis of only fatal cases and disease data (1,5) and others through hard efforts by investigator (3). Modern digital equipment permits us to carry out simultaneous monitoring of both human organism response and the variations of Heliogeophysical parameters. It is of great interest to recognize both global and local features of the response by direct measurements. The report presents studies of Heart Rate Variability (HRV) parameters response on geomagnetic field variations in Arctic and Antarctic regions, in which the Heliogeophysical disturbances are extremely manifested (4-6).

## Experiment and methods

The way to obtain information on the response of human organism to the geomagnetic factors is to carry out real time measurements of Heart Rate Variability (HRV) parameters and geomagnetic field variation in the same local place. The used HRV method was originally proposed by R. Baevsky (7). It was tested in the number of clinics over the world and confirmed by the World Health Organisation and advanced by both European Society of Cardiology and North American Society pacing and Electrophysiology [8]. In 1997-2001 the investigations were carried out in the vicinity of the Academician Vernadsky Ukrainian Antarctic Station (φ=65'15'' S, ϕ'≈ 64'16" W) and in the Polar Geophysical Institute, Apatity city on the Kola Peninsula (φ=68' N, ϕ'≈ 64, E). Parameters of local geomagnetic field variation were obtained from the observatories «Argentinee Islands» and Lovozero. HRV parameters of the tested people were obtained by industrial digital "Cardioanalyzer-ORI" and by "Cardioanalyzer-VR" monitor designed by V.Pivovarov [9]. 38 winterers of the Academician Vernadsky Ukrainian Antarctic Station and 28 volunteers of the Kola Science Centre in Apatity were invited for everyday recordings of their HRV parameters in several series of the experiments. Measurements of HRV were fulfilled at the same time of day in order to exclude the HRV circadian variations. HRV indices were calculated automatically according to verified algorithms [7-10] in order to characterise an adaptive power and functional status of individuals. Spectral analysis of HRV time series was used to obtain quantitative parameters of the response of the sympathetic and parasympathetic branches of autonomic nervous system (ANS). The spectral power of the heart rhythm at the frequency range of 0,15-0,4 Hz (High Frequency – HF) corresponds to the parasympathetic activity while the frequency range of 0,04-0,15 Hz (Low Frequency – LF) reflects the sympathetic influence. Below are results of analysis of more then 3000 cases of these measurements and their relationship with the geomagnetic field variations. The analysis was performed by traditional methods of mathematical statistics to obtain correlation coefficients, which characterised values with the significance level <0,05 lie. 95% probability if regression is present. The main parameters of HRV are taken into account as: HR (beat/s is heart rate; R-R (s) is a medial duration of heart intervals; σ ($s^2$) is variance of heart intervals; V (%) is a coefficient of variation; Amax (ms) is an extreme deviation of measuring R-R intervals time series; Amo (%) is a mode amplitude representing a relative amount of the modal value in R-R intervals time set; Mo (ms) is a mean value of R-R intervals distribution; $S_o$ is an amplitude of a spectrum of measured R-R intervals time series by (at) zero frequency; VLF (Very Low Frequency index) (ms2) represents HRV controlled by central contour; LF and

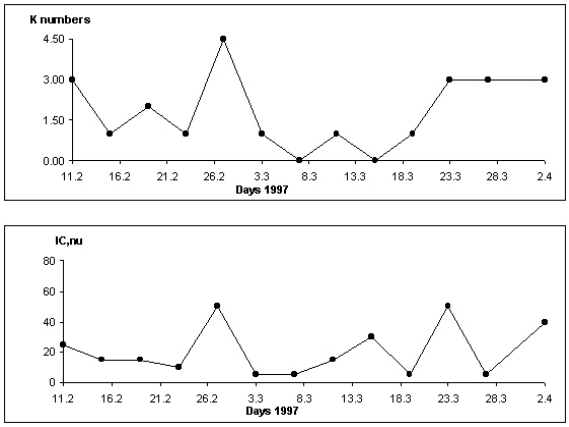



Fig.1 Local K index (18-21 UT) variations and average IC values modification of the tested winterers.

HF (see the description above) are in absolute (ms2) and normalised units (n.u.); SI (Amo/Amax×Mo) is a stress index, which is the most sensitive index of organism adaptation reaction to stress; $M_1$ is a value of an autocorrelation function at 1 shift; IC (VLF+LF/HF) – is an index of centralisation; IASS ($S_o$/HF) –is an index of activity of subcortical structures.

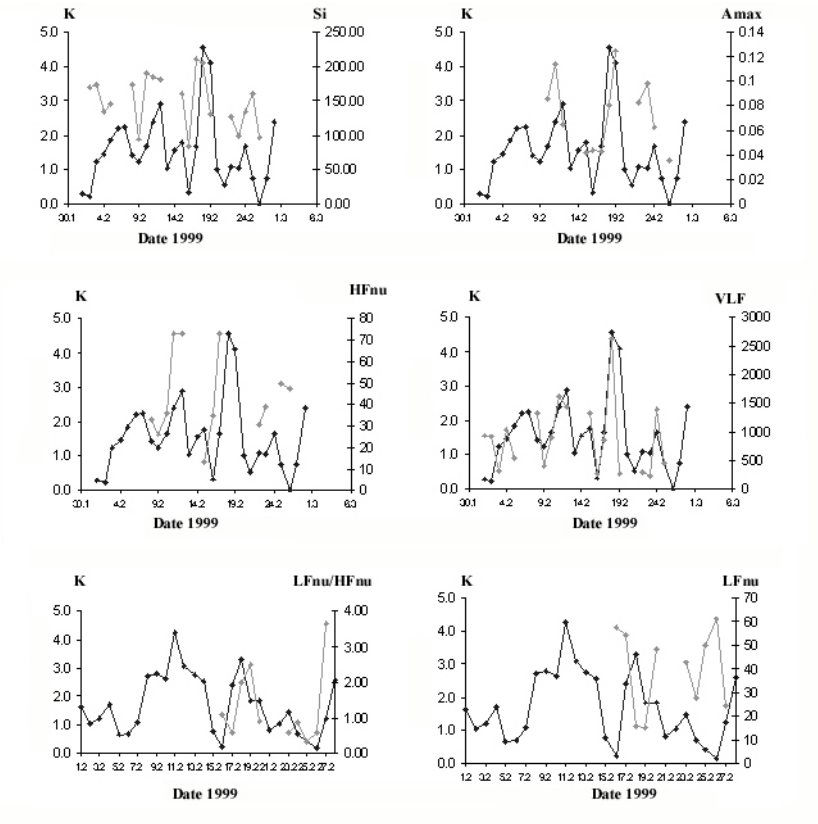



Fig. 2 Time dependencies of the local K indices (solid line) and different HRV parameters in the selected cases

## Results and discussion

It has been found that variations of geomagnetic activity in Antarctic impacts significantly ($P < 0,05$) wave structure and the degree of centralisation of the heart rhythm control. The positive correlation of the K-indices of geomagnetic activity with $M_1$ (r=0,6362), IC (r=0,6116) (Fig.1) and IASS (r=0,7016) is observed. The influences of the higher departments of the central nervous system on heart activity are strengthened with magnification disturbances of the geomagnetic field.

It has been found that spectral parameters of the time series of heart intervals (R–R intervals) were more sensitive to the influences of geomagnetic perturbations. In the area of Ukrainian Antarctic station, geomagnetic variations significantly influence the wave structure of the heart rhythm in 73 % of tested winterers.

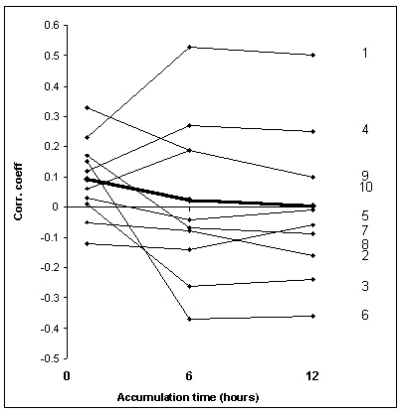
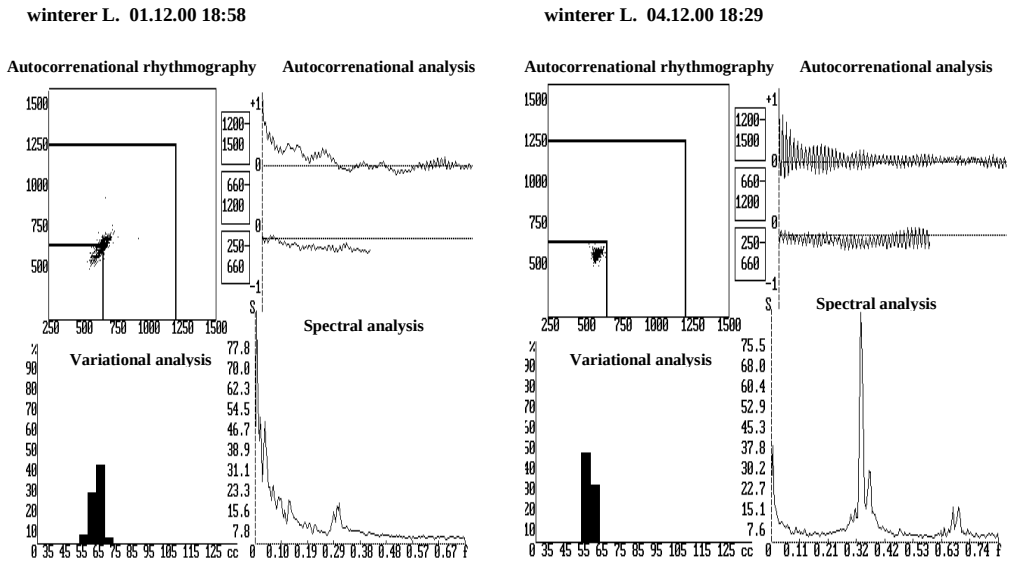


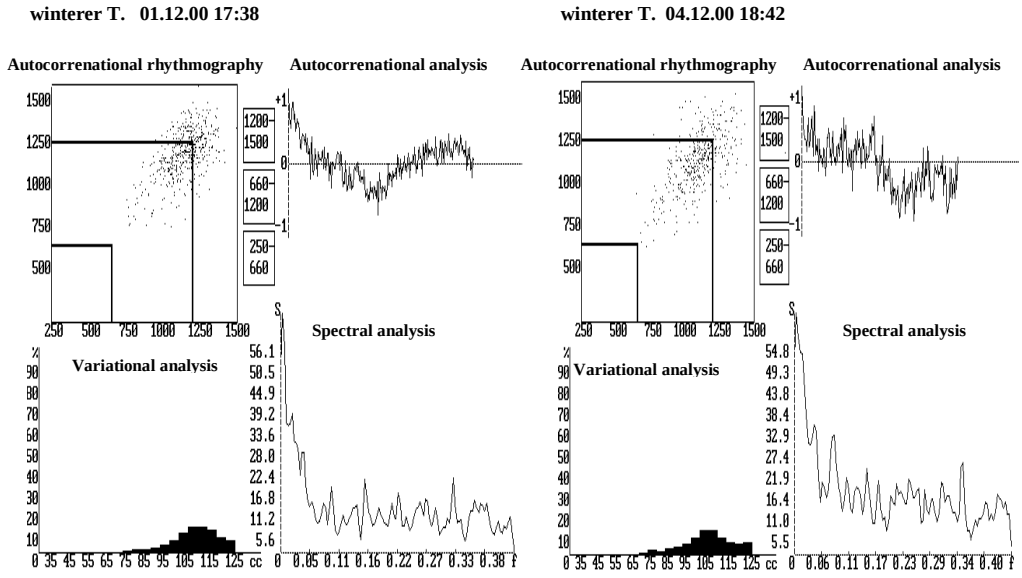

Fig.3 Relationship between accumulation time and correlation coefficient of HF (nu) and average for accumulation time K index

A similar situation takes place at the northern latitudes. Generalisation of Apatity volunteers HRV indices correlation with geomagnetic one hour K-indices at the Lovozero observatory shows that more than 65% of the tested people on average have HRV parameters dependence on geomagnetic field variation (Fig.2). The spectral indices (VLF, LF, HF) of R-R interval time series appear to be the most sensitive to the geomagnetic field variations values. The minimal reaction was registered in the heart rate data. It is necessary to take into account that reactions of human organism on geomagnetic disturbances can take place as accumulation or time delay events (3 ). The next day after intensive magnetic storm (K ~ 5) for 13% of winterers there occurred indications of unstable states of organism, from which spontaneous transitions to the states characterised by insufficiency or failure of adaptive mechanisms are quite possible (7). To study the impact accumulation effects the correlation coefficient between HRV parameters (HF as an example) and K index depending on accumulation time was constructed for 10 volunteers of Apatity (Fig.3 represents **r** for three accumulation times: 1, 6 and 12 hours). It is obvious that for some people r arise from 1 to 6 hours and then it is stabilised. Therefore, the time of about 6 hours is near the real HRV reaction time of individuals in presented cases. One can see from Fig.1, 2 the HRV responses are rather individual. It explains the earlier obtained result (3) where correlation of averages HRV indices with geomagnetic activity was rather poor. It seems that the study of the averaged by ensemble of tested people HRV time series is not so promising compared to the study of each individual response . The response intensity and direction depend, first of all, on the basis type of autonomic homeostasis, functional reserve and current status of the tested persons.

It was supposed and demonstrated [4,10,11] that the leading role of the reactions to the environment conditions could be played by the balance between the two branches of ANS. This balance is characterised by the balance




a) Dependence of the HRV parameters of the sympathetic tested winteres




b) Dependence of the HRV parameters of the parasympathetic tested winteres

Fig. 4 Examples of the reaction of HRV parameters of the tested winterers with different ANS accentuation durin weak (left side) and strong (right side) geomagnetic activity.

coefficient N=LF/HF. Thus, we need to carry out more intense studies of the dependence of different ANS branches on geomagnetic activity. Fig.4 represents spectral parameters of winterers with different status of ANS during weak and strong geomagnetic activity in Antarctic region. Geomagnetic disturbances were characterised by the daily sum of K as 9 for calm period (left part of Fig.4) and sum of K as 20 for disturbed day. As it possible to see that people with sympathetic and parasympathetic accentuation of ANS react to geomagnetic disturbances in a different way. For example HF, Amax, SI increase while So, LF decrease for people with sympathetic accentuation of ANS (SP) (Fig.4 top), and vice versa, Amax, SI decrease and So increase for people with parasympathetic accentuation of ANS (PP) (Fig 4 bottom) in similar geomagnetic activity situation. A similar situation is observed with volunteers having different ANS accentuation in Arctic region. Fig.5 presents time series of the Cosmic Rays activity, registered by the neutron monitor (CRM-cosmic rays monitor) in Apatity, when LF and HF parameters of HRV were registered. It is obvious that sympathetic (bottom of Fig.5) and parasympathetic (top of Fig.5) volunteer reactions of HF and LF are acting in opposite direction. It is necessary to emphasize that a very good correlation of

HRV and CR demonstrated here is connected supposedly with the so called Forbuesh effects, which characterised the global features of great geomagnetic storms.

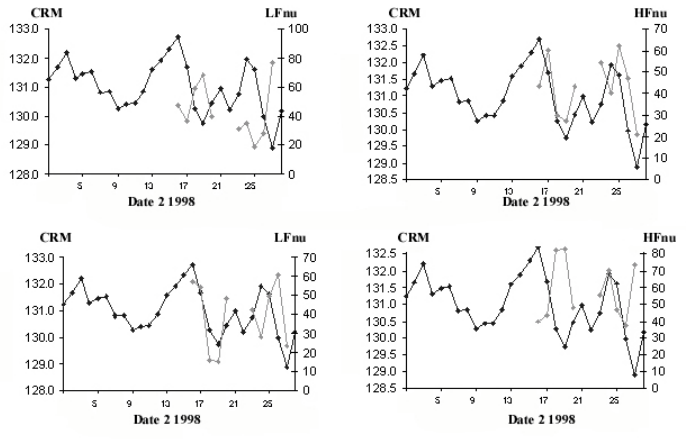



Fig. 5 Temporal variations of Cosmic Rays (solid line) and ANS parameters of HRV of sympathetic and parasympathetic volunteers in Apatity

## Discussion and Conclusion

Valid ($p<0.05$) correlation between K-indices, which describe the degree of the geomagnetic field disturbances and certain statistic and spectral parameters of HRV were shown. It has been found that spectral parameters of HRV were more sensitive to the influence of the geomagnetic perturbations. In the area of Academic Vernadsky Antarctic station the geomagnetic variations significantly influence the wave structure of the HRV in 73 % of the tested wintereres. More than 65% of people within the experimental situation underwent the impact of the geomagnetic field disturbances in the Kola Peninsula region. Statistical and spectral analysis demonstrate the correlation of autonomic nervous system (sympathetic and parasympathetic) indices as well as correlation of central regulation level index with geomagnetic field variation indices. The effects of accumulation of geomagnetic field variations impact on HRV is found and some time a delay between the impact of outer factors and reaction takes place for some people.

An increase of the magnetic field activity gives rise to centralisation of control over heart performance, which is probably connected with the activation of higher levels of central nervous system. In this case a shift of balance between sympathetic and parasympathetic influences is observed in the direction which depends on the basic type of autonomic homeostasis. It is necessary to point out that relationship between geomagnetic fields variations and HRV parameters is rather personal and varies in amplitude and direction for individuals depending on age and ANS accentuation, first of all. Possible effects of the doze and time delay reaction (3) are shown. Analysis of the obtained results does not give evidence that geomagnetic activity influences directly the human organism, because the mechanism of this impact has not been discovered yet. This influence could be produced by the impact of space weather on the atmospheric processes (for example on infrasonic waves (DEL). No doubt it is necessary to stress the expediency of use of the information about Heliogeophysical Disturbances for detection of the Auroral Disturbance Sensitive People (4,11) and the providing of preventive measures concerning their health, especially during their work at high latitudes. In any case one can use geomagnetic field variation as an indicator or marker of influence of Heliogeophysical Disturbances on Human Health.

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