

## ===== BIOPHYSICS =====

**HELIO-GEO-PHYSICAL EFFECTS IN DAILY PARAMETERS OF BACTERIA LIFE ABILITY.**

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The analysis of results of daily observations of frequency of colonies with differentiated sector or sectors [shortly named as CSD by Faraone since 1971, accordingly to Italian abbreviation] has allowed to establish a presence at their spectra of some known cosmophysical periods in air bacteria (1970-82) and also in laboratory strains of *Staphylococcus aureus* (1984-91).

The CSD are detected more often in days of negative polarity of an interplanetary magnetic field compared to positive. The ecological factor influencing on variability of bacteria has apparently an electromagnetic nature. Probably, the great value has increasing of geomagnetic micropulsations Pc1 (0,2 - 5 Hz).

**INTRODUCTION**

The first direct observations confirming possible influence of any physical agent connected with solar activity on parameters of life ability of bacteria have been received in 30-th by S.T.Velhover (1935) and G.Bortels (1940) (the bibliography of early publications see in [1,2]). These results did not attract an attention at all for a long time. However, A.L.Chizhevsky who by this time has collected and has generalized the data on connections between variations of solar activity and beginnings of epidemics and pandemics (A.L.Chizhevsky, 1930), was very interested in these results. Certainly, it was impossible to explain these results within the framework of physical contemplations of that time.

In the beginning of 70-s the association of parameters of life ability of microorganisms with solar activity has been established once again for soil bacteria (P.H.Rahno, 1971). Approximately during the same time the first results of the laboratory experiments specifying very high sensitivity of bacteria to changes in background electromagnetic fields of the lowest frequencies have been received (influence by artificial fields - H.Konig, L.Krempl-Lamprecht, 1959; J.N.Achkasova at al, 1969; electromagnetic shielding by H.Moriyama at al 1959; Achkasova at al, 1978). Association of deviations of nature electromagnetic environment with variations of solar activity was already actively discussed in the literature at that time (V.A.Troitskaja, A.V.Gulelmi, 1969).

Today it is clear, that influence of solar activity / space weather on the world of bacteria-viruses is very important for the forecast of approach of epidemics. It is surprising, that despite of the obvious practical value of understanding of this connection many aspects of it remain almost unexplored. Even the phenomenological picture of influence of solar activity on life ability of microorganisms remains rather incomplete. It does not allow answering, in turn, the basic question: which factors of habitat among supervised by solar activity make the most important contribution into discussed connection.

That is why it is expedient to return to consideration of one of the largest files of daily observations of microorganisms [air bacteria (1970-82) and *Staphylococcus Aureus* (1984-91)].

In the total these observations regard more than four millions of colonies and cover two 11-years cycles of solar activity. A frequency of occurrence of CSD that characterizes variability of bacteria was fixed. Earlier on the basis of the analysis of these data the following basic results [4-6] have been obtained: [Faraone, 1991; Faraone, 1995; Ormeni and Faraone, 1997]:

- Variations of number of CSD are represented with well enough reproduced phenomenon; clearly expressed annual course with a minimum in March, a maximum in November takes place; the

annual course is identical to a heterogeneous set of air bacteria and for laboratory strains of *S. Aureus*;

- For mid-annual values a negative correlation of an index of variability with Wolf numbers for air bacteria as well as for observations in laboratory takes place;
- Change of percent of sector colonies occur in Milan and Rome always utilizing the same technical methods and in respect to the same typical peculiarities of sampling site.
- In special measurements (November 1990), carried out synchronously a) at elevation of 1000 m above sea level, b) at same height, but under thickness of rocks of 1400 m (National Laboratory Gran Sasso) and c) on the sea level (Rome), it has been found, that at the mentioned elevation the index is reduced approximately on 20 %, and under a layer of rocks decreases in approximately two times.

The additional analysis which has been performed in [7,8], has allowed to make also the following conclusions:

- As for the various bacteria collected from air, as for strains of *St. Aureus* the index of variability shows the periods about 3.5d and about 7d (half of week and week); there are indications also to presence of the period about 45.5d. The period close to half of 11-years cycle (5.25Y) is found also;
- The index of variability shows statistically significant consistency at cross-correlation with indexes of magnetic activity Dst and Kp for the periods of 18.5d (open air bacteria) and 161.5d and 3.3d (strains of *S. Aureus*).
- During magnetic storms the index is reduced approximately at 10 %;
- The index of variability shows correlation with intensity of electromagnetic noise on the lowest frequencies (3 Hz), measured in Budapest.

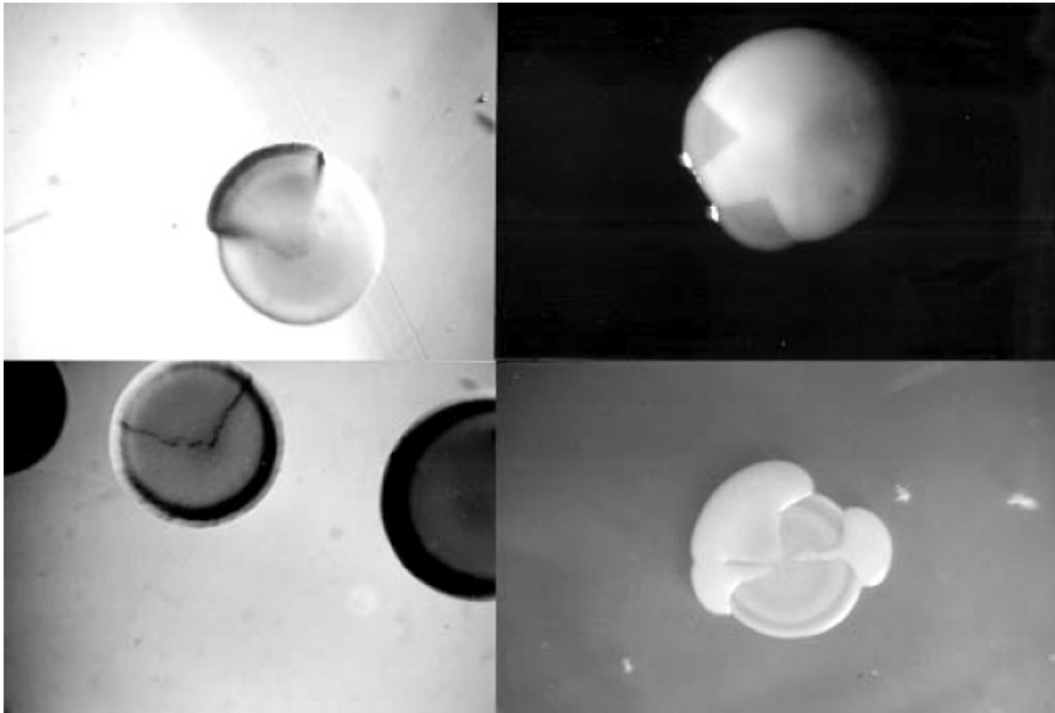
The received agreement of the analyzed separate periods in spectra of variability of microorganisms and various helio-geo-physical indexes requires further research in this direction to obtain the most complete picture of possible statistical relations, including spectral correlations. The purpose of the given work was comparison of a full set of the basic periods in spectra of variability of air bacteria and strains *S. Aureus* with a set of the basic helio- and geophysical periods.

The second, not less important goal of the given work was research of possible effect of passing of sector borders of interplanetary magnetic field (IMP) which now is reliably established in geophysical processes, biology, medicine [8]. Presence (absence) of similar effect in an index of variability of bacteria gives additional opportunities for finding the physical nature of the working agent.

## MATERIALS AND METHODS.

The technique of gathering of air bacteria (it is in detail described in [4, 6]) consists in the following: tests collected daily, in an interval from 10 to 16 of local time, within generally 30-60 minutes, at height of 25 m above ground by method of sedimentation on a disk (Petri plates of diameter 90 mm) with agar substrate (Agar Tryptose Difco) and then incubation in standard conditions. Further a percent of CSD among total number of grown colonies was counted. The colonies counted CSD if they were looking like the filled circle containing at least one or more sectors different from "parental" strain by standard visual characteristics: color, transparency, the type of a surface, etc. (fig.1).

Occurrence in the given colony of several various sectors was possible. Each time, using moderate magnification, 200-250 colonies daily of air bacteria and 300-350 colonies daily of *S.Aureus* strains, medially were studied. Air Bacteria were miscellaneous bacteria and were simply grouped in spore bearing bacteria, in cromogenes-bacteria with colored colonies and in micrococcaceae. The different frequency of CSD was considered in these grouping to select more opportunely the bacteria to utilizing after in the test of laboratory, from 1984 to 1991. The *S.Aureus* strains were classified by species.



**Fig. 1.** Examples of anomaly colonies with CSD: top right – two sectors have higher transparency, then the rest of the colony, others – sectors have bigger size and / or different color comparing to the rest of colony.

Every day the percent of CSD among all bacteria colonies grown on surface of Agar Tryptose Petri plates was counted. The biological nature of occurrence of sectors is not discussed, the obtained percent of CSD is simply considered as the general parameter of phenotypic variability of microorganisms to detect a possible physical parameter (as Solar Activity or Cosmic Rays or ELF-fields, etcetera) that may be correlated with the CSD frequency. In 1970-75 the data were gathered in Milan and in 1976-82 under the same conditions in Rome. In 1984-91 similar observations were carried out in laboratory conditions (Rome) for various strains of *S.Aureus*.

Calculation of functions of spectral density for all numbers was made by method of Fourier transformation of autocorrelation function after subtraction of low-frequency trend (periods over two years).

Files of the daily data of an index of variability of air bacteria contained rather significant missing portions (approximately 10-12 % of all data). Filling these missing values have been produced utilizing standard procedures of statistical package MESOSAUR (approximation by polynomials of the second degree using the method of least squares with exponentially reduced weights). For data sets of variability of *S.Aureus* missing values made very insignificant part of the data (<1 %), therefore procedure of their filling could not bring in essential distortion to a spectrum of capacity. Calculation of spectral density functions for all data sets was performed by method of Fourier transformation of autocorrelation function using MATLAB 6.5.

To detect possible effects of change of sign of radial component of IMP in variations of percentage of CSD we used data about moments of passing sector borders of IMP presented in the addendum to the monograph [Sidjakin *at al.*, 1985] and at the web site <http://www.izmizan.rssi.ru/magnetism/SSIMF/index.htm>. The meaning and implication of radial component of IMP as helio-geo-physical index is discussed extensively in the other article of this issue [Odintsov and Konradov, 2005], where you can find also examples of usage of this index and relative bibliography.

We used the method of superimposed epochs where the last day of long (>4 days) period of constant sign was used as a zero day. Transitions from positive polarity to negative, and reversed ones were considered separately.

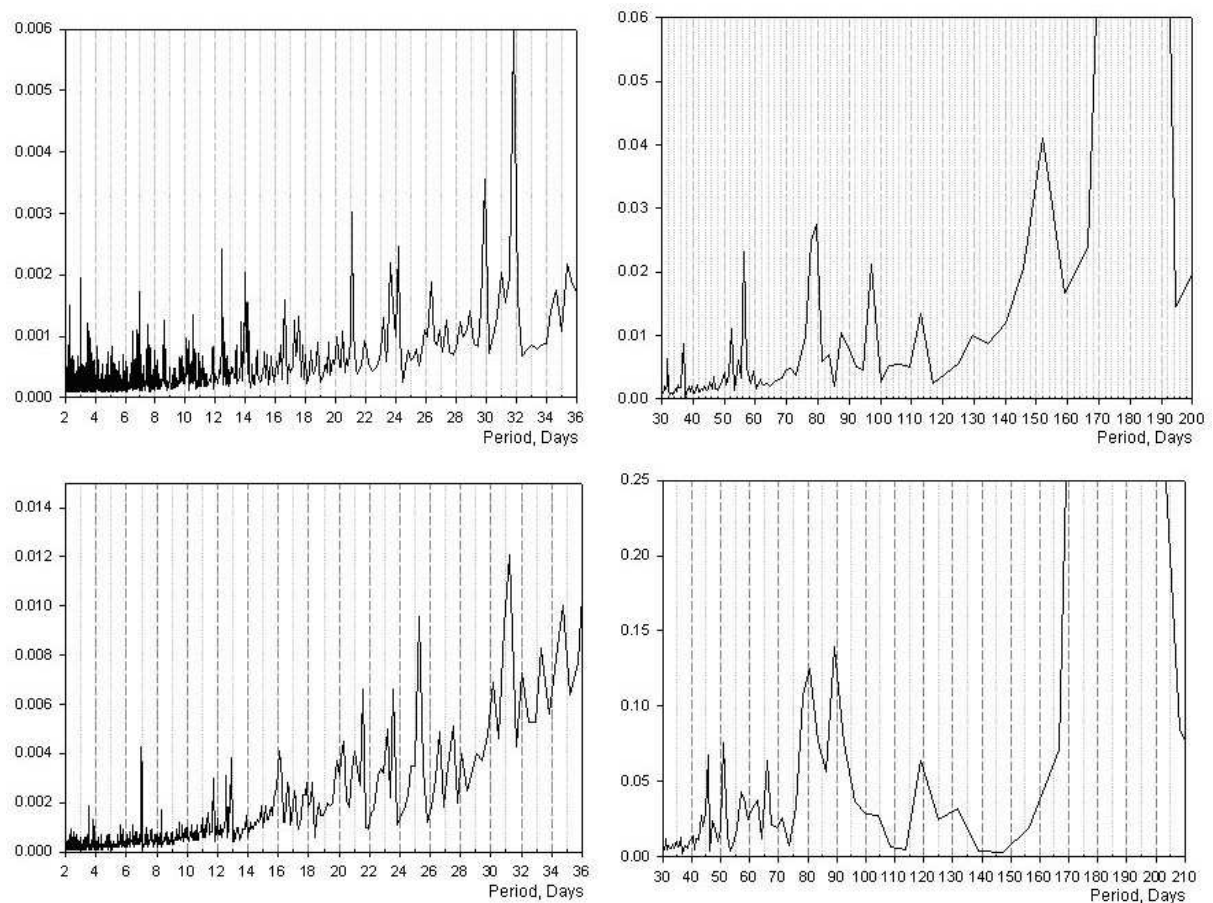
## RESULTS

*Cosmo-physical rhythmic in variations of frequency of occurrence of CSD.*

In figure 2 the functions of spectral density calculated for sets of numbers of CSD in air bacteria (above) and *S.Aureus* (below) are resulted. Values of all allocated periods including about half-year are shown in Table 1 (in days).

The statistical significance of the periods listed above was estimated by calculation of corresponding spectra of Fisher. The periods with significance of 0.01 are marked by \*. Other periods are less significant. However, all of them, probably, are real, because they are present practically at all spectra received on independent fragments of the data, and their values coincide with reasonable accuracy with values of cosmophysical periods. The annual period is also present in all spectra. Well-known in cosmophysics-geophysics quasi-biannual cycles are boldly arise in observations of air bacteria and laboratory strains of *S. Aureus* K1 and K2.

The most important conclusion, which can be made out of consideration of Tab. 1, is that in all series of observations the same set of the periods takes place. Noticed only two exceptions: the period of chromospheric flashes of 154 +/-2 days is present only for air bacteria; the period ~44d is found only in laboratory observations. Such good consistency is surprising, as analyzed subsets belong to different cycles of Solar activity – even and odd. Besides, values of all these periods, as is known, noticeably grow (approximately 10 %) at transition from minima of Solar activity to maxima.



**Fig. 2.** Functions of spectral density for data sets of air bacteria (above) (1970-1982) and *S. Aureus* (1984-1990) - below. Vertical axis is spectral density, horizontal axis are values of the periods in days.

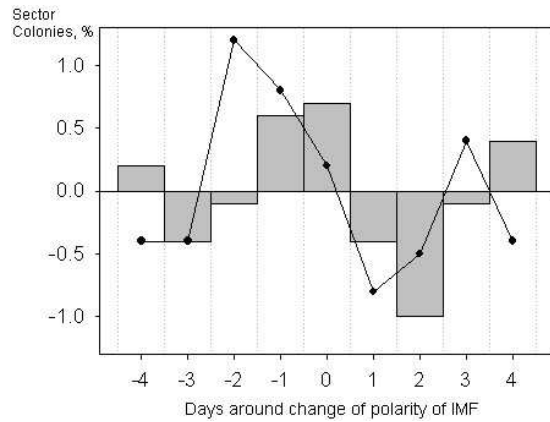
Table 1.

The periods (day) which has been observed in cosmo-physical indexes [Vladimirsky, 1984]	Air bacteria Milan - Rome, 1970-1982.	Staphylococcus aureus, observation in laboratory			
		All strains, 1984-1991	Some strains, 1986-1990		
			K1	K2	K3
3,5	3.5	3,5	4	--	3
7,0	7	7,0	6.5	6.5	6, 7
9.1	8.5	--	9.5	--	8, 9
12.5	12.5	12	--	12	--
13,7	14	13	13.5	14	13.7, 14
16.5	16.5	16	16, 17.5	--	16, 17.5
22,0	21	21.5	20	21	21
27,0±3	27	23.5, 25	--	24, 27	23, 25
	31	31	31	31	30
35	36	36	34	34	35, 39
44		45	44	48	44
53	54	51	--	--	52
		66	68	69	--
	78	79	78	78	--
	97	92	100	100	
119 (122)		120	122	--	120
153	152	--	--	--	--
180	182	182	180	182	180

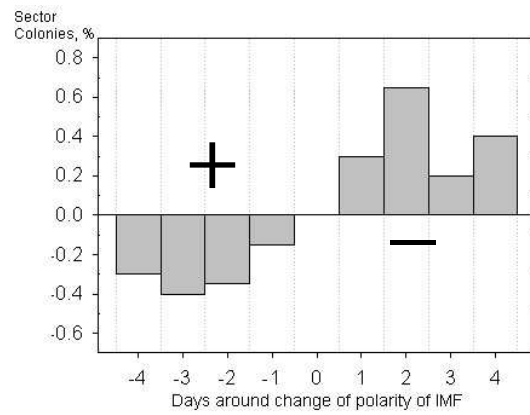
***Variations in frequency of occurrence of abnormal colonies and a sign of radial component of interplanetary magnetic field***

A specially made catalogue of the so-called "well defined" borders of sectors of interplanetary magnetic field (the sign on the field remains constant for at least four days on both sides of the border) included the lists of these borders published in the Appendix of the monograph [Sidjakin *et al.*, 1985] – 1970-1980. Further the list has been continued up to 1991 on the basis of IZMIRAN data (it has been established, that the overlapped data are consistent).

For revealing actual effect of a sign change of interplanetary field at long observation it is important to take into account some trivial parasitic variations caused, for example, by change of polarity of the general field of the Sun and seasonal changes. These last are important in this case because of already mentioned negative correlation between an analyzed biological parameter and magnetic activity. According to a known rule, a positive sign on an interplanetary field is geo-effective (i.e. it is accompanied by increase of a geomagnetic index) in the autumn, negative polarity – in the spring [Ponjavin, Usmanov, 1985]. From fig. 3 it is visible, that the specified rule is observed for the analyzed data 1970 – 1982: the structure of change of percent of CSD appears the same at transition “-“ → “+” and “+” → “-“ accordingly for spring and autumn (by consideration of these schedules it is necessary to remember that indexes of magnetic activity grow after passing IMF sector border. Increase of these indexes is accompanied by reduction of a biological parameter).



**Fig. 3.** Variations of percent of CSD before and after the moment of change of polarity of interplanetary magnetic field. Superimposing of epoch. Vertical axis is percent of abnormal colonies (a deviation from an average). The histogram is transition “+” → “-“, spring, n=28; a broken line is transition “-“ → “+“, autumn, n=32



**Fig. 4.** Average values of percent of CSD before and after day of change of polarity of interplanetary magnetic field. Borders of different types are incorporated. Superimposing of epoch. All data of 1970-78 when the general magnetic field of the Sun did not change a sign is used. Distinction of average for days of different polarity is significant according to Mann-Witney U-test at a level 0.014.

The main effect is shown at figure 4. It is obtained by averaging of both types of borders (n=86), transition “-“ → “+“ was reversed around zero day. Apparently, the biological parameter in days of positive polarity at all days remains below average, negative – is higher. At calculations only the data before change of polarity of the general magnetic field of the Sun were used (Sun polarity changed about 1979, process of inversion according to optical observation has come to the end by the autumn 1980). After that event the effect should change a sign. It has been checked particularly for a corresponding part of the given data file (the end of 1979-1982 the general number of borders n=30). It appears, that the effect of asymmetry shown on fig. 4, at this time definitely was absent (a conclusion about change of a sign was statistically non-significant).

Observation of *St. Aureus* falls to an epoch of other polarity of the general magnetic field of the Sun, so the effect of interplanetary field also should have an opposite sign. Because of scarce data this effect has not been found with full confidence. All figures are shown in tab. 2. In the first line of the table the effect of polarity of interplanetary field is submitted separately for a situation when there is no seasonal effect – the Earth is projected at this time on helio-equator (helio-latitude of the Earth is  $\pm 2^\circ$ , these epochs fall to June and December). The presented deviations are standard deviations of mean value for days of the given polarity of interplanetary field. The statistical significance was calculated according to Mann-Witney U-test (P (U\*)). It revealed in tab. 2, that effect of change of polarity of interplanetary magnetic field for air bacteria is established with full certainty. Probably the same effect is present also at laboratory observation of *St. Aureus*. In 70th in days of positive polarity of interplanetary magnetic field variability of aerobacteria “was suppressed”, in days of negative – “was stimulated”.

**Table 2.**

Sample	Air bacteria 1970-78				<i>St. aureus</i> in the lab 1984-91			
	Number of borders	Interplanetary magnetic field “plus”	Interplanetary magnetic field “minus”	P(U*)	Number of borders	Interplanetary magnetic field “plus”	Interplanetary magnetic field “minus”	P(U*)
Zone $\pm 2^\circ$ , Helio-equator	18	-1.16 $\pm$ 0.81	+1.11 $\pm$ 0.98	<b>0.01</b>	9	+0,10 $\pm$ 1,39	-0,26 $\pm$ 1,51	0,34
All data	86	-0.30 $\pm$ 0.10	+0.42 $\pm$ 0.16	<b>0.01</b>	32	+0,28 $\pm$ 0,48	-0,36 $\pm$ 0,26	0,17

## DISCUSSION

The basic result obtained above is useful for comparing to results of the similar analysis of influence of a sign of interplanetary field on other bacterial tests-reactions. At the same time, certainly, it is necessary, that observations corresponded to the same sign of the general magnetic field of the Sun – only then a direct comparison is reasonable. It appears, that in 70th in days of negative polarity the CSD grew, speed of duplication of *E.coli* decreased [Achkasova *et al.*, 1982], rate of agglutination of bacteria *Salmonella typhimurium* increased, and speed of sedimentation of colloid solution in modified test F (Piccardi) raised [Opalinskaya & Agulova, 1984].

At the analysis of the data of G. Piccardi [Vladimirsky, 1989] all measurements 1951-67 were analyzed in one file, therefore, most likely, direct comparison is impossible. But nevertheless pertinently to remind that precise connection with interplanetary field has been found only for test F. Tests P and D definitely have not been found to have such association. For test F parameter T decreased in negative polarity. Active “factor” in days of negative polarity influenced the activated water, i.e. the water preliminary processed by a low-frequency electromagnetic field [Opalinskaya & Agulova, 1984]. As soon as in Piccardi experiments the object of EMF influence was water, similarity of structures of these two reactions allows to come out with the assumption, that factor directly working in an inhabitancy influences not only biological structure, but also the liquid environment. In this case water acts as the universal receiver of super-weak electromagnetic ecological influences [Capel-Boute, 1985]. Last years reasons have appeared as theoretical [Kislovsky, 2002], as laboratory experimental ones [Lednev, *et al.*, 2003] for the benefit of such a point of view.

### *In search of the working factor - ranging of hypotheses*

Today the analysis of cosmophysical correlations for these or other organisms or eco-systems is carried out within the framework of the concept of biological action of micro-dozes of physical factors and chemical agents [Burlakova *at al.*, 2003]. In habitat the large number of ecological parameters depends (as a rule, very weakly) on variations of Solar activity (changes of space weather). There is a problem arises to allocate really working factor from all potentially possible ones. At the same time it is necessary to take into account properties of the given factor and established for the given biological parameter the phenomenological attributes of associations with solar activity.

With reference to a parameter considered here – frequency of occurrence of CSD – some ecological parameters can be excluded at once from the further consideration as insignificant. They are the following:

*Changes of intensity of ground ultra-violet radiation* (connected with Solar activity through dynamics of ozonosphere) can be not discussed further because correlations for atmospheric microorganisms, soil bacteria and laboratory observations are practically the same, though in laboratory observations and for ground this agent is completely excluded;

*Electric field of an atmosphere and its fluctuations* may be excluded for the same reasons – they don't penetrate laboratory rooms;

*Ultra weak variations of gravitation field* may not be shielded at all, including by rocks. In geophysical measurements there are no regular gravitational anomalies during development of magnetic storms or change of polarity IMF;

*Variations of galactic cosmic rays* possess a number of features which are well coordinated to the constructed phenomenological picture: a) cosmic rays are the mutagen, bringing approximately 15% of a total doze of an irradiation to an organism in a habitat; b) their spectrum contains the same set of the multi-days periods, as percent of CSD; c) for 11-years cycle of solar activity increase in intensity of cosmic rays is accompanied by increase in percent of CSD; d) for magnetic storms the CSD index falls (about 10 %), that corresponds to reduction of a stream of cosmic rays (about 5 %). However last three arguments are characterized by correlations and can speak the general dependence of two compared parameters on some general third factor. Besides other features of variations of space beams contradict a hypothesis about their role as the major factor determining frequency of occurrence of abnormal colonies: a) with increase in elevation the stream of cosmic rays grows, but frequency of occurrence of CSD falls (20 %); b) at the big depth underground cosmic rays as the working agent "are switched off" – its intensity falls up to the rate

corresponding to one particle per one cell (the size about micron) at time of millenia! But the index of variability in this case does not fall up to zero, decreasing only twice.

*Amplitude-spectral variations of low-frequency electromagnetic fields* remain, thus, the unique possible candidate for a role of the factor directly influencing probability of occurrence CSD against which for the present moment there are no serious arguments (in all details this hypothesis, with reference to various biological systems, including cells, is discussed in [Vladimirsky & Temurjants, 2000]). However it would be useful, using phenomenological laws to define, which electromagnetic phenomenon can play a significant role in this case. A number of similar features is traced in this case with behavior of geomagnetic micropulsations in a frequency strip 0,2÷5 Hz (Pc1 or "pearls"): a) radiowaves on the specified frequency are absorbed by thickness of rocks of 1400 m very little; b) these fluctuations on frequency of occurrence negatively correlate with Wolf's numbers (as well as CSD); c) the annual course of their duration is in phase with a course of an index of variability – in winter the value of both indexes is at the average higher, than in the summer, d) changes of intensity of these micropulsations near days of change of polarity of interplanetary magnetic field are very similar to fig. 3 (more details see in [Matveeva, etc., 2001], asymmetry by sign of interplanetary field for Pc1 was not studied).

Thus, the hypothesis about the electromagnetic nature of directly working agent is the most argued from all discussed opportunities. However such identification should not be considered as confidently-unequivocal. For several strains of *St.aureus* their significant correlation of DNA-activity with critical frequencies of F2-ionosphere [Shestopalov, et al., 1997] has been found out. If at the further researches similar communication will be established for other microorganisms (and other parameters), it will mean, that solar activity can influence bacteria simultaneously in several frequency ranges. In a similar situation the electromagnetic signal responsible for variations of number of abnormal colonies, can appear much more complex, can not be limited, in particular, to occurrence of superfluous emission only in a frequency range of Pc1.

## CONCLUSIONS.

Additional processing and the subsequent analysis of daily observations of variability (occurrence of CSD ) of air bacteria (1970-82) and laboratory strains of *Staphylococcus Aureus* (1984-91) have allowed making the following basic conclusions:

1. In fluctuations of frequencies of occurrence of CSD the wide spectrum of known cosmophysical periods is presented.
2. CSD in 1970-79 appear more frequently at negative polarity of interplanetary magnetic field in comparison with positive. The observed effect is very similar to effect of change of polarity of interplanetary field in G.Piccardi's F-tests.

The conclusion is made after discussion of various hypotheses that the ecological factor directly influencing bacteria, most likely, represents amplitude-spectral changes of an electromagnetic background of habitat controllable by solar activity. Probably, excitation (attenuation) of geomagnetic micro pulsations Pc1 (a range of frequencies 0,2 ÷ 5 Hz) in magnetosphere plays the important role.

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