

## Hypo-Magnetic Problems of the Deep Space Missions

Mikhail Panasyuk<sup>1\*</sup>, Andrey Spassky<sup>1</sup> and Kirill Trukhanov<sup>2</sup>

<sup>1</sup>Skobeltsyn Institute of Nuclear Physics, Lomonosov Moscow State University, Russia

<sup>2</sup>Institute of Medical and Biological Problems RAS, 76a, Khoroshevskoe Shosse, Moscow, 123007, Russia

### Introduction

Currently, the adverse effects of ultra-low magnetic fields on biological objects and, in particular, human beings, are universally recognized. That is why in Russia for the first time in the world the restrictions on limit values of the coefficient of attenuation of the geomagnetic field (GMF) at workplaces, residential and public buildings were brought into action. Deep space manned missions will happen under such hypo-magnetic conditions (GMC) and therefore their impact on the crew requires urgent attention along with other adverse factors of such a flight.

### Discussion

During the manned flight at distances exceeding the radius of the Earth over ten times (for example, to the moon, to Mars), the crew and bio regenerative life support system (BSA) for a long time will remain in the interplanetary magnetic field, the value of which is 103-105 times less than regular GMF. First of all it will lead to the influence of intensive fluxes of the charged particles of the solar and galactic cosmic rays, most of which are rejected by GMF during the near-Earth flights, on the crew. Second, people during the flight will face new factor - the extremely low GMC. However, the mechanisms of influence of GMF on biological objects are still not completely clear, although they are studied for about half a century [1].

Electromagnet to biology is a science that studies the influence of electromagnetic fields on biological structures including theoretical and experimental aspects of this problem. Currently, it became clear that the absence of the usual electromagnetic fields (especially geomagnetic) entails the effects generally unfavorable. There is still no generally recognized theory of these effects. But there are different approaches to the explanation of possible mechanism of noticeable effects of ultra-low electromagnetic fields at molecular and sub molecular level.

Despite certain difficulties in the theoretical explanation of GMC influence mechanisms on biological macro objects there is a relatively wide range of experimental data confirming this effect on the simplest biological objects (such as bacteria and single-celled), and on the upper objects, including humans, and as noted above, this effect is usually negative. For example, under the GMC the intensity of the fission of planaria changes, the behavior of the rat communities also changes (experimental study of the Institute of Biology and Biophysics of Tomsk State University) [1,2]. In the above experiment with rats an inappropriate aggressive behavior of the groups under the GMC was observed compared to the control one. At the everyday language their behavior can be characterized as "crazy". What will happen to the cosmonauts or astronauts under GMC influence?

The effect of GMC on biological objects under growth is particularly strong. The results of the experiments performed with Japanese quail eggs (MSU, IBMP RAS) indicated significant variance in the early stages of embryo development [3].

However, it can be noted that there is still no large-scale systematic studies of the GMC effect on various biological objects, including humans, despite the pressing need for such works. It is not obvious that

the negative impact of state musical compounded by the increased level of attenuation of the field. Moreover, there are the findings of nonlinear character of influence of the GMC on the development of organisms (in particular, embryos Japanese quail).

Virtually no studies of the simultaneous effects of ionizing radiation caused by the fluxes of the charged particles of the solar and galactic cosmic rays (particularly, heavy ions) and GMC was conducted, while in deep space both these factors are present.

First experiments performed in MSU by a 120-cm cyclotron, with alpha-particles with energies of 30.5 MeV, revealed that the negative influence of ionizing alpha radiation on single-celled organisms cyanobacterium *Synechocystis* sp. PCC 6803 enhanced greatly by prior restraint in GMC [4]. Alpha particles provided the value of the linear energy transfer of about 20 keV/mcm, i.e. simulated the ionizing ability of relativistic nuclei of carbon-magnesium groups of cosmic rays.

It should be noted that the problem of the GMC influence on the crew is not relevant to the near-Earth flight because of the relatively small weakening of the Earth's magnetic field. For example, for the maximum distance from the Earth's surface of 450 km (approximate orbit of the ISS), the weakening of the induction of the geomagnetic field does not exceed 20% compared to the value at the surface of the Earth.

### Conclusions

For the foreseeable period the most real projects of the deep space missions are the flight to Mars orbit and relatively long stay on the lunar surface. Proceeding from the above, it is necessary to protect the spacecraft, the crew and BSA from the conditions of very weak magnetic field compared to the usual value at the Earth's surface. For instance, it is possible to generate the necessary field in a relatively small volume, and apparently it is not a big problem. Such calculations are underway. It seems promising that this local magnetic field will protect the inhabitants of the spacecraft and the lunar base, providing there magnetic conditions like on the Earth's surface.

### References

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\*Corresponding author: Mikhail Panasyuk, Skobeltsyn Institute of Nuclear Physics, Lomonosov Moscow State University, Russia, Tel: 7-495-939-1818; E-mail: [panasyuk@sinp.msu.ru](mailto:panasyuk@sinp.msu.ru)

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