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The ”Radiation Barrier” for manned missions into deep space and NICA project

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The concept of risk currently used when considering the idea of deep space flights is represented by a generalized dosimetric functional as the criterion and quantitative measure of the danger of space types of radiation. The generalized dose comprises the doses inducing the immediate and long-term effects. The immediate radiation-induced effects develop during the flight, while the long-term ones, during later life. To calculate the dose for the immediate and long-term effects of radiation exposure, the coefficients are introduced that express the influence of the following factors on the radiobiological effect: the quality of radiation (including protons and heavy charged particles of different energy), time distribution of the dose, human body distribution of the dose, and modification of the organism's radiation response due to other flight factors. As the immediate radiation exposure effects, considered are the disorders of marrow hematopoiesis, cutaneous covering, and other organs and tissues of the organism. Regulations usually associate the long-term effects of cosmonauts' radiation exposure with the development of neoplastic processes in the organism, the risk of tumor development being considered the main adverse consequence for the interplanetary flights. At the same time, it should be noted that heavy charged particles of the galactic cosmic rays (GCR) have a highly destructive effect on the biological structures – they have to be considered an extremely dangerous radiation factor that can cause crew's operator activity disorders already during the flight. This approach is supported by results of the experiments in which animals (rodents) were irradiated at charged particle accelerators at doses matching real fluxes of GCR heavy nuclei during a flight to Mars: in the post-irradiation period, disorders of spatial orientation and cognitive functions were observed (Rabin B. M. et al., 2004; Britten R.A. et al., 2012; PariharV.K. et al., 2015). The authors link these neurobiological effects to a glutamatergic synaptic transfer disorder – first of all, in hippocampus neurons. This is also indicated by the data showing a decrease in the level of a number of other neurotransmitters in different brain parts and behavioral reaction disorders in rodents after heavy ion irradiation (Stemberg A.S. et al., 2015). In experiments on 500 MeV/nucleon carbon ion irradiation of primates (Macaca mulatta) at a dose of 1 Gy, a reliable decrease of cognitive functions and the concentrations of metabolites (in particular, serotonin) was observed in animals of the excitable unbalanced type of higher nervous activity (Belyaeva et al., 2015). To take into account the high biological effectiveness of high-energy heavy charged particles in radiation risk evaluation for manned interplanetary flights, the concept of "the successful completion of the mission" was introduced (A.I. Grigoryev, E.A. Krasavin, M.A. Ostrovsky, 2015). Unlike the currently used radiation risk concept, which brings into the foreground the risk of cancer development – the long-term effects of the exposure, the new paradigm is concerned, first of all, with the risk of disorders of higher integrative functions of the crew members' central nervous system. These disorders can impair cosmonauts' operator functions already during the flight and endanger the successful completion of the mission. The possibility of using NICA accelerator complex to simulate the biological effect of cosmic radiation is discussed in the report.

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