

CONTENTS

RESULTS OF THE ISS CREW MISSIONS

- Main Results of the ISS-52/53 of Expedition Training and Activity When Carrying out the Mission Plan. *S.N. Ryazanskiy, A.A. Kuritsyn, A.I. Kondrat, V.A. Kopnin, D.E. Rybkin, E.I. Korzun* 5
- Medical Support of the ISS-52/53 Crew Members (Express Analysis). *V.V. Bogomolov, V.I. Pochuev, I.V. Alferova, E.G. Khorosheva, V.V. Krivolapov* 20

THEORY AND PRACTICE OF HUMAN SPACE FLIGHTS

- Cosmonaut Training for Emergency Situations Aboard the Space Station. *S.V. Bronnikov, A.Ye. Malikov, I.A. Rozhkova* 35
- On One Approach to the Solution of the Spacecraft Descent Problem in the Earth's Atmosphere. *M.A. Dzhabarov, N.E. Zubov* 46
- Some Issues of Improving Extravehicular Activity of Cosmonauts. *A.A. Altunin, D.I. Verba, P.P. Dolgov, E.Yu. Irodov, V.S. Korennoy, Yu.I. Onufrienko* 64
- Reasoning of the Possibility to Use a Fermented Milk Probiotic Product for Mitigating Health Risks During Long-Term Space Missions. *A.I. Kobatov* ... 81

HISTORY. EVENTS. PEOPLE

- Human Factors in Aviation and Space Exploration. *T.B. Nesterovich, A.A. Medenkov, N.M. Kozlova* 99

SCIENTIFIC-INFORMATION SECTION

- The Joint ESA-Roscosmos "Plasma Cristall-4" Experiment On-Board the International Space Station. *V.E. Fortov, O.F. Petrov, A.D. Usachev, A.M. Lipaev, A.V. Zobnin, V.I. Molotkov, M.Yu. Pustyl'nik, H.M. Thomas, M.H. Thoma, E.O. Serova, A.M. Samokutyaev, G.I. Padalka, O.D. Kononenko, A.N. Ovchinin, A.A. Ivanishin, O.V. Novitsky, S. Cristoforetti* 115
- The Database «Activities of the ISS RS's Crews for the Maintenance of Delivered, Return and Disposable Cargo». *B.I. Kryuchkov, V.I. Yaropolov, V.I. Gorlova* 133

UDC 629.78.007

Main Tasks of Training and Results of Activity of the ISS Crew for Expedition 52/53 When Carrying out the Mission Plan

S.N. Ryazansky, A.A. Kuritsyn, A.I. Kondrat, V.A. Kopnin, D.E. Rybkin, E.I. Korzun

Abstract. The paper considers results of the ISS-52/53 crew activity aboard the Soyuz-MC-05 spacecraft and the ISS. Main tasks of the research program carried out by the crew are given. The tasks carried out in the course of extravehicular activity are reviewed.

Keywords: tasks of crew training, spaceflight, International Space Station, scientific applied research and experiments.

REFERENCES

Ryazansky Sergey Nikolayevich – Hero of the Russian Federation, Pilot-Cosmonaut of the RF, Test-Cosmonaut Instructor, FSBO “Gagarin R&T CTC”

E-mail: info@gctc.ru

Kuritsyn Andrey Anatolievich – Doctor of Technical Sciences, Associate Professor, Head of Department, FSBO “Gagarin R&T CTC”.

E-mail: info@gctc.ru

Kondrat Andrey Ivanovich - Deputy Head of Department, FSBO “Gagarin R&T CTC”.

E-mail: A.Kondrat@gctc.ru

Kopnin Vadim Anatolievich – Division Head, FSBO “Gagarin R&T CTC”.

E-mail: V.Kopnin@gctc.ru

Rybkin Dmitriy Evgenyevich – Subdivision Head, FSBO “Gagarin R&T CTC”.

E-mail: D.Rybkin@gctc.ru

Korzun Elena Ivanovna – Junior Reseacher, FSBO “Gagarin R&T CTC”.

E-mail: E.Korzun@gctc.ru

UDC 61:629.78.007

Medical Aspects of Securing the Flight of the ISS Crew for Expedition 52/53 (Express Analysis)

V.V. Bogomolov, V.I. Pochuev, I.V. Alferova, E.G. Khorosheva, V.V. Krivolapov

Abstract. The paper shows the results of medical support of the ISS crew for Expedition 52/53 and gives a brief description of operation of the medical support system and maintaining the stability of human environment aboard the ISS RS. Besides, the paper sums up results of the implementation of medical recommendations, program of medical monitoring and the use of onboard facilities meant to prevent the alteration of cosmonauts' health status in spaceflight.

Keywords medical support, medical monitoring, preventive system, human environment, work/rest schedule.

REFERENCES

Bogomolov Valery Vasilievich – Doctor of Medical Sciences, Professor, State Science Center of the Russian Federation – Institute of Biomedical Problems of the RAS.

E-mail:

Pochuev Vladimir Ivanovich – Candidate of Medical Sciences, Senior Researcher, Department Head-Physician of the highest category, FSBO “Gagarin R&T CTC”.

E-mail: V.Pochuev@gctc.ru

Alferova Irina Vladimirovna – Candidate of Medical Sciences, Leader of the mission medical support group, State Science Center of the Russian Federation – Institute of Biomedical Problems of the RAS.

E-mail:

Khorosheva Elena Grigorievna – Senior Researcher, State Science Center of the Russian Federation – Institute of Biomedical Problems of the RAS

E-mail:

Krivolapov Vladimir Vsevolodovich – Senior Researcher, State Science Center of the Russian Federation – Institute of Biomedical Problems of the RAS

E-mail:

UDC 629.78.007

Cosmonaut Training for Emergency Situations Aboard the Space Station

S.V. Bronnikov, A.Ye. Malikov, I.A. Rozhkova

Abstract. The paper considers the problems of training cosmonauts for emergency situations, argues the necessity of training crews in flight, gives the on-board simulator structure and describes the process of on-board training.

Keywords: space station, crew safety, training, skills, level of preparedness, on-board simulator, training tasks, methods of on-board training.

REFERENCES

- [1] Alexandrov A.P., Bronnikov S.V. How to Improve the Efficiency of a Spacecraft Crew's Activity // Polyot. All-Russian Scientific and Technical Journal. – 2005. – No 1. – pp. 11–16.
- [2] Bronnikov S.V., Rozhkova I.A. Emergency Simulator // Report of the XLIV Scientific Readings of the Memory of K.E. Tsiolkovsky, Kaluga, September 15–17, 2009. – pp. 100–101.
- [3] Implementation of Training the Cosmonauts Aboard the “MIR” Orbital Complex Via Radio Channels of Intercomputer Information Exchange / S.V. Bronnikov, S.N. Samburov, L.G. Shevchenko, M.V. Tyurin // XXXI Scientific Readings Devoted to Development of Creative Heritage of K.E. Tsiolkovsky (Kaluga, September 17–20, 1996). – 145 p.
- [4] Development of Onboard Training Simulators for Manned Orbital Stations / Bronnikov S.V., Salnitsky V.P., Shevchenko L.G. // Coll. of Proceedings of the Scientific and Technical Workshop. – Issue 4. Technical Facilities and Technologies for Constructing Simulators. – October 10–11, 2002, 3Star City. – 129–130 pp.
- [5] Lomov B.F. Man and Technology: Essays on Engineering Psychology / B.F. Lomov – Moscow: Book on demand, 2012. – 464 p.
- [6] Psychodiagnostic Complex-Simulator for Evaluating and Predicting the Reliability of a Cosmonaut's Professional Activity / Salnitsky V.P., Bronnikov S.V., Gorodetsky I.G. // Pribory. – 2008. –No 4. – 23–28 pp.
- [7] Study of Reliability of a Cosmonaut's Activity at Different Stages of a Space Flight (Experiment “Pilot”) / Salnitsky V.P., Myasnikov V.I., Bobrov A.F., Shevchenko L.G., Dudukin A.V. // “Mir” Orbital Station. Space Biology and Medicine. – Vol. 2. Medical and Biological Experiments. – Moscow: GNTs RF–IMBP RAS, 2002. – pp. 285–300.
- [8] A Guide to the Space Flight Safety / G.T Beregovoy [and others]. – Moscow: Mashinostroyeniye, 1998.

Bronnikov Sergey Vasilievich – Candidate of Technical Sciences, PC “S.P. Korolev Rocket and Space Corporation – Energia”

E-mail:

Malikov Andrey Yevgenievich – Division Head, FSBO “Gagarin R&T CTC”

E-mail: A.Malikov@gctc.ru

Rozhkova I.A. - PC “S.P. Korolev Rocket and Space Corporation – Energia”

E-mail:

On One Approach to Solving the Problem of the Spacecraft Descent in the Earth's Atmosphere

M.A. Dzhabarov, N.E. Zubov

Abstract. An analytical solution of the problem of tracking the programmed descent trajectory of spacecraft in the Earth's atmosphere under the lateral control was obtained for the sixth-order mathematical model. For this purpose, a regulator was synthesized using the poles precise placement method. The numerical simulation results of tracking the programmed descent trajectory from the moment of entering the atmosphere to opening the parachute landing system are presented.

Keywords: spacecraft, descent, Earth's atmosphere, nominal trajectory, control law.

REFERENCES

- [1] Evdokimov S.N., Klimanov S.I., Korchagin A.N., Mikrin Ye.A., Sikharulidze Yu.G. Terminal algorithm for controlling an axial motion of the descent module with the load factor limiting // *News of the RAS. Control theory and systems.* – 2012. – № 5. – P. 102–118.
- [2] Yaroshevsky V.Ya. Entry of space vehicles into atmosphere. – M.: Nauka, 1988.
- [3] Okhotsimsky D.Ye., Golubev Yu.F., Sikharulidze Yu.G. Algorithms for controlling a space vehicle at entering atmosphere. – M.: Nauka, 1975.
- [4] Zubov N.Ye., Mikrin Ye.A., Ryabchenko V.N. Matrix methods in the theory and practice of aircraft automatic control systems. – M.: Publishing house of Bauman MSTU, 2016. – 666 p.
- [5] Zubov N.Ye., Mikrin Ye.A., Ryabchenko V.N., Oleynik A.S., Yefanov D.Ye. Estimation of the spacecraft angular rate in the orbital stabilization mode based on the measurements of the local vertical sensor // *Bulletin of Bauman MSTU. Series "Priborostroyeniye".* – 2014. – № 5. – P. 3–17.
- [6] Zubov N.Ye., Zybin Ye.Yu., Mikrin Ye.A., Misrikhanov M.Sh., Proletarsky A.V., Ryabchenko V.N. Controlling the spacecraft motion spectrum by an output // *News of the RAS. Control theory and systems.* – 2014. – № 4. – P. 111–122.

Dzhabarov M.A. – Mathematician Engineer, PC "S.P. Korolev Rocket and Space Corporation – Energia"

E-mail:

Zubov Nikolay Yevgenievich – Doctor of Technical Sciences, Professor, Chief Researcher, PC "S.P. Korolev Rocket and Space Corporation – Energia"

E-mail:

Some Issues of Improving Extravehicular Activity of Cosmonauts

A.A. Altunin, D.I. Verba, P.P. Dolgov, V.S. Korennoy, Yu.I. Onufrienko

Abstract. The paper discusses some problems of carrying out actual tasks of extravehicular activity by cosmonauts, such as: launch of small spacecraft, jettisoning of the used equipment, photographing and video filming of equipment, instruments and elements on the outer surface of the station. Also, it presents proposals on the development of new technical facilities for performing specific extravehicular tasks and improving cosmonaut training.

Keywords: extravehicular activity, small spacecraft, launching facility, jettisoned object, photographing, video filming, simulator for cosmonaut training.

REFERENCES

- [1] Main Results of EVA Performed by the ISS Crews / B.I. Kryuchkov, A.A. Altunin, P.P. Dolgov, V.I. Yaropolov, V.M. Usov, E.Yu. Irodov, D.I. Verba, V.S. Korennoy // *Manned Space Flights* – № 1 (22). – 2017.
- [2] Approach to the Grounding of the Tasks for Robotic Systems to Work in Open Space / P.P. Dolgov, E.Yu. Irodov, V.S. Korennoy // *Manned Space Flights.* – № 3 (16). – 2015.
- [3] New Directions in Robotics for the Purposes of Manned Cosmonautics / Kryuchkov B.I., Usov V.M. // *Manned Space Flights.* – 2013. – № 1 (6). – 93–100 pp.
- [4] Safe Use of a Space Robotic System During Extravehicular Activity / V.S. Korennoy, P.P. Dolgov, E.Yu.

- Irodov // Manned Space Flights. – № 1(18). – 2016.
- [5] Will a Robot Replace a Cosmonaut in Performing EVA Operations / Tsygankov O.S., Babaytsev D.V. // Manned Space Flights. – 2012. – № 2 (4). – 74–87 pp.
- [6] Statistical Analysis of Mass and Dimensions Parameters of Scientific Equipment Installed by Cosmonauts During Extravehicular Activity / Irodov E.Yu., Dolgov P.P., Korennoy V.S. // Manned space flights. – 2015. – № 4(17).
- [7] Hardware for Launching Small Space Vehicles. [Text]; Patent. 153436 Rus. Federation, MIIK B64G 1/64 / Dolgov P.P., Irodov E.Yu., Korennoy V.S., Applicant and Patent Holder “Gagarin Research&Test CTC”. – № 2015103959/11; applic. 06.02.15; publ. 20.07.15, Бюл. № 20. – 2 p.: il.
- [8] Small Space Vehicle for Monitoring the Space Station. [Text]; Patent 157041 Rus. Federation, MIIK B64G 1/10 / Dolgov P.P., Irodov E.Yu., Korennoy V.S., Altunin A.A., Applicant and Patent Holder “Gagarin Research&Test CTC”. – № 2015103958/11; applic. 06.02.15; publ. 20.11.15, Bulletin № 32. – 2 p.: il.
- [9] Simulator of Operating a Small Space Vehicle. [Text]; Patent 158082 Rus. Federation, MIIK G09B 9/08. / Dolgov P.P., Irodov E.Yu., Korennoy V.S., Applicant and Patent Holder “Gagarin Research&Test CTC”. – № 2015116944/11; applic. 06.05.15; publ. 20.12.15, Bulletin № 35. – 2 p.: il.

Altunin Aleksey Alekseyevich – Deputy Head of Department (for cosmonaut training for extravehicular activity), FSBO “Gagarin R&T CTC”

E-mail: A.Altunin@gctc.ru

Verba Dmitry Ivanovich – Deputy Head of Division, FSBO “Gagarin R&T CTC”

E-mail: D.Verba@gctc.ru

Dolgov Pavel Pavlovich – Candidate of Technical Sciences, senior researcher, Deputy Head of Department (for research and tests), State organization “Gagarin R&T CTC”

E-mail: P.Dolgov@gctc.ru

Irodov Evgeny Yuryevich – Candidate of Technical Sciences, Leading Researcher, FSBO “Gagarin R&T CTC”

E-mail: E.Irodov@gctc.ru

Korennoy Viktor Sergeevich – Candidate of Technical Sciences, senior researcher, FSBO “Gagarin R&T CTC”

E-mail: V.Korennoy@gctc.ru

Onufrienko Yury Ivanovich – Candidate of Technical Sciences, Head of Department, FSBO “Gagarin R&T CTC”

E-mail: Y.Onufrienko@gctc.ru

UDC 579.65

Substantiating the Possibility to Use a Fermented Milk Probiotic Product for Mitigating Medical Risks during Long-Term Space Missions

A.I. Kobatov

Abstract. The paper discusses the issues relating to the influence of space flight factors on biological characteristics of microorganisms included as the members of exomicroflora (microorganisms staying at the atmosphere inside the spacecraft) and of endomicroflora (microorganisms colonizing a cosmonaut gastrointestinal tract). It was shown that the microorganisms can change their characteristics under conditions of a high radiation background aboard a space vehicle. This produces extra technical and health risks for crew members. The paper presents an approach to mitigate health risks through production and use of acidophilic probiotic product, possessing an immunomodulatory effect, directly aboard a space vehicle.

Keywords: exomicroflora, endomicroflora, ionizing radiation, health risks, probiotic, acidophilic product, *Lactobacillus acidophilus*.

REFERENCES

- [1] Complex Research Performed by Faculty of Biology of M.V Lomonosov Moscow State University under the Federal Space Program (“Manned Space Exploration”) aboard the ISS / Alekhova T.A., Aleksandrova A.V., Zakharchuk L.M. and others. // Book of Abstracts “Scientific Researches and Experiments Aboard the ISS”. –

- April 9–11, 2015. – M. – P. 107–108.
- [2] Baraboy V.A. Popular Radiobiology. – Kiev: Naukova Dumka, 1988. – P. 189.
- [3] Dertinger G., Yung H. Molecular Radiobiology. – M.: Atomizdat, 1973. – P. 14.
- [4] Vorobyova L.I., Abilev S.K. Antimutagenic Properties of Bacteria (Review) // Applied Biochemistry and Microbiology. – 2002. – V. 38. – № 2. – P. 115–127.
- [5] Effects of *Lactobacillus* Type Bacteria on the Production of Cytokines by Cells of Peyer's Patches of Experimental Animals / Zorina V.V., Nikolaeva T.N., Narovlyanskiy A.N. // Immunology. – 2004. – № 5. – P. 288–290.
- [6] Zryachkin N.I. A New Approach to the Classification of Prebiotics, Probiotics and Synbiotics // Pharmateka. – 2007. – № 2. – P. 58–61.
- [7] Using «Vitaflor» Probiotic to Reduce the risk of Opportunistic Microflora Carriage in Case of Radiation Injury / Ivanov A.A., Simbirtsev A.S., Maltsev V.N. and others. // Medicine of Extreme Situations. – 2013. – № 1(43). – P. 76–81.
- [8] Colonization Resistance of Organism Under Changed Habitat Conditions / Ilyin V.K., Volozhin A.I., Vikha G.V. – M.: Nauka, 2005. – P. 275.
- [9] Probiotic "Vitaflor" as a Possible Means of Protecting Cosmonauts From the Negative Consequences of Nuclear Radiation Effect / Kobatov A.I., Verbitskaya N.B., Dobrolezh O.V., Petrov L.N. // Medicine of Extreme Situations. – 2007. – № 2 (20). – P. 72–79.
- [10] Results of SE "Bioemulsiya" and SE "Laktolen" Aboard the ISS Russian Segment in the Period From 2007 to 2013. / Kobatov A.I., Evstigneev V.I., Gureeva E.A., Verbitskaya N.B., Dobrolezh O.V. // Scientific Researches and Experiments Aboard the ISS: Book of Abstracts. – M., 2015. – P. 100–101.
- [11] Parker Yu. How to Defend Space Explorers // In the World of Science. – 2006. – № 6. – P. 15–20.
- [12] Pinevich A.V. Microbiology. Biology of Prokaryotes. Textbook in 3 Volumes. – V. 2. – St. Petersburg University Press, 2007. – P. 330.
- [13] Reznik N.L. Microbes that Effect on Nerves // Chemistry and Life. – 2012. – № 6. – P. 40–42.
- [14] Rush K., Peters U. Intestine – the Control Center of Immune System // Biomedicine. – 2003. – № 3. – P. 4–8.
- [15] Tsyolkovskiy K.E. Philosophy of Space Age. – M.: Academic Project, 2014. – P. 238.
- [16] Human. Biomedical Data. – M.: Meditsina, 1977. – P. 493.
- [17] Autoprobiotic Therapy / Chicherin I.Yu., Pogorelskiy I.P., Lundovskikh I.A. and others. // Journal of Infection. – 2013. – V. 5. – № 4. – P. 43–54.
- [18] Experimental Pseudotuberculosis: Evaluation of Possibility to Prevent and Treat Dysbiotic Disorders of Intestinal Microflora / Chicherin I.Yu., Pogorelskiy I.P., Lundovskikh I.A. and others. // Gut Flora From the Inside Out: Innovative Collection of Scientific Articles. – 2013. – Issue № 2. – P. 124–129.
- [19] Khoroshilova N.V. Immunomodulatory and therapeutic effects of probiotics // Immunology. – 2003. – № 6. – P. 352–356.
- [20] Yarmonenko S.P., Vaynson A.A. Radiobiology of Humans and Animals. – M.: Vysshaya Shkola, 2004. – P. 549.
- [21] Bodana A.R., Rao D.R. Antimutagenic Activity of Milk Fermented by *Streptococcus Thermophilus* and *Lactobacillus Bulgaricus* // J. Dairy Sci. – 1990. – Vol. 73. – P. 3379–3384.
- [22] Dugas B., Mercenier A. Immunity and Probiotics // Trends Immunology Today. – 1999. – Vol. 20(9). – P. 387–390.
- [23] Hosoda M., Hashimoto H. Antimutagenicity of Milk Cultured with Lactic Acid Bacteria Against N-Methyl-N-Nitro-N-Nitrosoguanidine // J. Dairy Sci. – 1992. – V. 75. – P. 976–981.
- [24] <http://alcala.ru/medicinskaya/slovar-P/123619.shtml>.
- [25] <http://ria.ru/science/20150904/1229302695.html> /
- [26] <http://readings.gmik.ru/lecture/2001>
- [27] <http://www.horizonpress.com>.
- [28] <http://www.km.ru/front-projects/amerikanzi-nikogda-ne-letali-na-lunu/vyhe-24-000-km-nad-zemlei-radiatsiya-ubivaet-vse-zhivoe>
- [29] Kekkonen R. Immunomodulatory Effects of Probiotic Bacteria in Healthy Adults. Academic Dissertation, Helsinki, Finland. – 2008. – P. 119.
- [30] Matar Ch., Nadathur S.S. Antimutagenic Effects of Milk Fermented by *Lactobacillus Helveticus* L 89 and a Protease-Deficient Derivative // J. Dairy Sci. – 1997. – V. 80. – P. 1965–1970.
- [31] Nadathur S.R., Gould S.J., Bakalinsky A.T. Antimutagenicity of Fermented Milk // J. Dairy Sci. – 1994. – Vol. 77. – P. 3287–3295.
- [32] NATO ASI Series. Vol. H 98 Lactic Acid Bacteria: Current Advances in Metabolism, Genetics and Applications. – Edited by F. Bozoglu and B. Ray: Springer. – Berlin. – 1996. – P. 1–136.
- [33] Ng S.C., Hart A.L., Kamm M.A. Mechanisms of Action of Probiotics: Recent Advances // Inflamm. Bowel Dis. – 2009. – Vol. 15(2). – P. 300–309.
- [34] Novikova N.D. Review of the Knowledge of Microbial Contamination of the Russian Manned Spacecraft // Microbial Ecology. – 2004. – Vol. 47. – Issue 2. – P. 127–132.

Kobatov Aleksey Ivanovich – Candidate of Technical Sciences, Senior Researcher, FSUE "National Research Institute for High Purity Biologicals" of FBMA of Russia, St. Petersburg
E-mail:

Human Factors in Aviation and Space Exploration

T.B. Nesterovich, A.A. Medenkov, N.M. Kozlova

Abstract. The paper analyses materials of the conference “Human factors in aviation and space exploration: formation and importance of taking them into consideration” and provides information about the directions and results of psychophysiological studies in domestic aviation medicine in the pre- and post-war periods. Research data on biomedical training for the first space flights is given. The contribution made by national specialists in the preparation and implementation of the space flight of Yuri Gagarin is shown. The peculiarities of developing a methodology of taking into account the psychophysiological capabilities of a human in aviation and spaceflight are considered. The topical problems subject to be resolved in the interests of further space exploration and preparation of interplanetary expeditions are identified.

Keywords: human factor, space flights, ergonomic software, psychology, functional status, psychophysiological reliability.

REFERENCES

- [1] Recovery of functional status after space missions / Baranov V.M., Medenkov A.A., Nesterovich T.B. // Human factor: the problems of psychology and ergonomics. – 2017. – № 3/2. – pp. 52–62.
- [2] About the rest of cosmonauts in flight / Bubeev Yu.A., Nesterovich T.B., Medenkov A.A. // Human factor: the problems of psychology and ergonomics. – 2017. – № 3/2. – pp. 62–67.
- [3] Flight personnel training for maneuvering and altitude flights / Bukhtiyarov I.V., Dvornikov M.V., Filatov V.N., Khomenko M.N. // Human factor: the problems of psychology and ergonomics. – 2017. – № 3/2. – pp. 77–84.
- [4] Contribution of scientists of the Institute of Aviation Medicine to improving combat capabilities of flight personnel during the Great Patriotic War. / Vasilyev P.V., Denisova T.V., Medenkov A.A. // Aviation and space medicine, psychology and ergonomics. Collected papers. – M.: Polyot, 1995. – pp. 12–20.
- [5] Contribution of scientists of the Institute of Aviation Medicine to ensuring combat capabilities of flight personnel prior to the Great Patriotic War / Vasiliev P.V., Medenkov A.A., Rysakova S.L., Denisova T.V. // Thesis report of the 10th Moscow International Conference. Simpos. on the History of Aviation and Cosmonautics, Moscow, June 20-27, 1995. – M.: IHST RAS, 1995. – pp. 32–33.
- [6] Issues of aviation medical support / Executive editor Kulikovskaya G.G. Collection of research papers. – V. 1. – M.: Voenizdat, 1939. – P. 224.
- [7] Issues of aviation medical support / Executive editor S.I. Subbotnik. Collection of research papers – V. 2. – M.: Voenizdat, 1939. – P.176.
- [8] L.G. Golovkin’s contribution to the development of high-altitude physiology and ergonomics in aviation and cosmonautics (to the 90th anniversary of his birth) / Golovkina O.L., Dvornikov M.V., Rusaliev K.Ya. // Human factor: the problems of psychology and ergonomics. – 2017. – № 3/2. – pp. 16–22.
- [9] Psychophysiological characteristics and human capabilities in terms of domestic aviation and cosmonautics / Dvornikov M.V., Zhdanko .I.M., Medenkov A.A. // Human factor: the problems of psychology and ergonomics. – 2017. – № 3/1. – pp. 8–13.
- [10] Infrastructure for insuring ergonomics in the process of professional activity / Dvornikov M.V., Medenkov A.A., Nesterovich T.B. // Human factor: the problems of psychology and ergonomics. – 2017. – № 3. – pp. 40–44.
- [11] Psychophysiological resources and safety enhancement reserves of flights / Dvornikov M.V., Medenkov A.A., Nesterovich T.B. // Military-medical Journal – 2017. – № 3. – pp. 51–58.
- [12] Dvornikov M.V., Medenkov A.A., Olenev N.I. Medical and technical support of flight safety // Human factor: the problems of psychology and ergonomics. – 2017. – № 3/1. – pp. 31–37.
- [13] G.P. Ovechkin’s contribution to the training of aviation physicians / Dvornikov M.V., Medenkov A.A., Frantsuzov V.N. // Human factor: the problems of psychology and ergonomics. – 2017. – № 3/2. – pp. 36–38.
- [14] Development of methodology for high-altitude flights in aviation and cosmonautics / Dvornikov M.V., Medenkov A.A., Shishov A.A. // Human factor: the problems of psychology and ergonomics. – 2017. – № 3/1. – pp. 52–58.
- [15] Development of methodology of psychological selection in aviation / Zatsarny N.N., Medenkov A.A., Pokrovsky B.L., Tretyakov N.V. // Human factor: the problems of psychology and ergonomics. – 2017. – № 3/1. – pp. 62–68.
- [16] Managing the development of labor psychology, engineering psychology and ergonomics in domestic aviation. // Human factor: the problems of psychology and ergonomics. – 2017. – № 3/1. – pp. 46–51.
- [17] The Institute of Aviation Medicine and the main directions of its research / Kibabshina M.A., Medenkov A.A., Moskvicheva N.L., Nesterovich T.B. // Current problems of aviation and space medicine. Proceedings of the All-Russian Scientific and Practical Conference, St. Petersburg, December 16–17, 2013 – SPb.: VMEDA, 2013. – pp. 66–67.
- [18] Development of methodology for determining the causes of flight accidents / Kozlov V.V., Kosolapov O.A., Fedoruk A.G. // Human factor: the problems of psychology and ergonomics. – 2017. – № 3/1. – pp. 68–72.

- [19] Relevance of considering human factor in aviation / Kozlova N.M., Dvornikov M.V., Medenkov A.A., Nesterovich T.B. // Human factor: the problems of psychology and ergonomics. – 2017. – № 3/2. – pp. 47–52.
- [20] Features of activity of deck aviation personnel / Mastryukov A.A., Melnik S.G., Plakhov N.N. // Human factor: the problems of psychology and ergonomics. – 2017. – № 3/2. – pp. 68–72.
- [21] Medenkov A.A., Milovanova M.A. Research of the Institute of Aviation Medicine in pre-war period. // K.E. Tsiolkovsky and innovative development of cosmonautics. Proceedings of the XLVIII Scientific readings in memory of K.E. Tsiolkovsky, Kaluga, September 17–19, 2013. – Kaluga: Eidos Publ., 2013. – pp. 130–131.
- [22] Relevance of considering human psychophysiology in aviation / Medenkov A.A., Dvornikov M.V., Nesterovich T.B. // Human factor: the problems of psychology and ergonomics. – 2017. – № 1/1. – pp. 59–63.
- [23] Biomedical training for manned space flights / Medenkov A.A., Kibabshina M.A., Kaspranskiy R.R. // Human factor: the problems of psychology and ergonomics. – 2017. – № 3/1. – pp. 18–26.
- [24] Development of national ergonomics in aviation and cosmonautics / Medenkov A.A., Malofeev A.A., Rybnikov O.N., Sapegin A.N. // Human factor: the problems of psychology and ergonomics. – 2017. – № 3/1. – pp. 26–31.
- [25] Current biomedical problems of manned space flights (based on the proceedings of the International Conference "Manned Space Exploration") / Medenkov A.A., Nesterovich T.B., Kozlova N.M. // Aerospace and Ecol. Medicine. – 2017. – V. 51, № 3. – pp. 78–84.
- [26] History of the Institute of Aviation Medicine / Medenkov A.A., Nesterovich T.B., Rysakova S.L. // Human factor: the problems of psychology and ergonomics. – 2017. – № 3/1. – pp. 14–18.
- [27] Theory and practice of human factor in aviation and cosmonautics / Medenkov A.A., Nesterovich T.B., Stepanov V.S. // Human factor: the problems of psychology and ergonomics. – 2017. – № 1/1. – pp. 54–59.
- [28] N.D. Zavalova's contribution to the development of aviation engineering psychology / Medenkov A.A., Oboznov A.A., Nesterovich T.B. // Human factor: the problems of psychology and ergonomics. – 2017. – № 1/1. – pp. 42–45.

Nesterovich T.B. – National Research University “Moscow Aviation Institute”

E-mail:

Medenkov Aleksandr Alekseevich – Doctor of Medical Sciences, Candidate of Psychology, Professor

E-mail:

Kozlova N.M. – Doctor of Technical Sciences, Associate Professor, National Research University “Moscow Aviation Institute”

E-mail:

UDC 537.5

Joint ESA-Roscosmos Experiment called “Plasma Cristall-4” aboard the International Space Station

V.E. Fortov, O.F. Petrov, A.D. Usachev, A.M. Lipaev, A.V. Zobnin, V.I. Molotkov, M.Yu. Pustynnik, H.M. Thomas, M.H. Thoma, E.O. Serova, A.M. Samokutyayev, G.I. Padalka, O.D. Kononenko, A.N. Ovchinin, A.A. Ivanishin, O.V. Novitsky, S. Cristoforetti

Abstract. The new “Plasma Cristall-4” space experiment (“PC-4” SE) jointly conducted by the European Space Agency (ESA) and Roscosmos on-board the International Space Station (ISS) is described. “PC-4” SE has been operating on-board the ISS since June 2015 and is intended to proceed with research of the fundamental properties of highly non-ideal plasma-dust systems under zero-gravity conditions and development of new technological applications. The conducting of experiments is regulated by a special Agreement between ESA and Roscosmos on the Joint “PC-4” SE in the “Columbus” European Laboratory Module. Content of the flight and ground parts of the “PC-4” scientific equipment (SE), design of the gas-discharge experimental chamber and main parameters of the dusty plasma experiment as well as scheme of controlling the performance of the experiment aboard the ISS, international cooperation while conducting “PC-4” SE and its first results from the orbit are presented.

Keywords: dusty plasma, gas discharge, dusty plasma structures, scientific equipment.

REFERENCES

- [1] Chu J.H., Lin I. Direct Observation of Coulomb Crystals and Liquids in Strongly Coupled rf Dusty Plasmas // *Physical Review Letters*. – 1994. – Vol. 72. – No 25. – P. 4009–4012.
- [2] Thomas H., Morfill G.E., Demmel V., Goree J., Feuerbacher B., Mohlmann D. Plasma Crystal-Coulomb Crystallization in a Dusty Plasma // *Physical Review Letters*. – 1994. – Vol. 73. – No 5. – P. 652–655.
- [3] Hayashi Y., Tachibana K. Observation of Coulomb-Crystal Formation from Carbon Particles Grown in a Methane Plasma // *Japanese Journal of Applied Physics part 2-letters*. – 1994. – Vol. 33. – No 6A. – P. L804–L806.
- [4] Fortov V.Ye., Nefedov A.P., Torchinsky V.M., Molotkov V.I., Khrapak A.G., Petrov O.F., Volykhin K.F. Dusty Plasma Crystallization in the Positive Glow // *JETP Letters* – 1996. – V. 64. – № 2. – 89–91 p.
- [5] Fortov V.Ye., Nefedov A.P., Vaulin O.S., Lipaev A.M., Molotkov V.I., Samaryan A.A., Nikitsky V.P., Ivanov A.I., Savin S.F., Kalmykov A.V., Solovyov A.Ya., Vinogradov P.V. Dusty Plasma, Induced by Solar Radiation, Under Micro Gravity Conditions: an Experiment Aboard the «Mir» Station // *JEPT*. – 1998. – V. 114. – № 6(12). – 2004–2021 p.
- [6] Nefedov A.P., Vaulina O.S., Petrov O.F., Molotkov V., Torchinskii V.M., Fortov V.E., Chernyshev A.V., Lipaev A.M., Ivanov A.I., Kaleri A.Y., Semenov Y.P., Zaletin S.V. The Dynamics of Macroparticles in a Direct Current Glow Discharge Plasma Under Micro-Gravity Conditions // *New Journal of Physics*. – 2003. – Vol. 5. – P. 108.
- [7] Nefedov A.P., Morfill G.E., Fortov V.E., Thomas H.M., Rothermel H., Hagl T., Ivlev A.V., Zuzic M., Klumov B.A., Lipaev A.M., Molotkov V.I., Petrov O.F., Gidzenko Y.P., Krikalev S.K., Shepherd W., Ivanov A.I., Roth M., Binnenbruck H., Goree J.A., Semenov Y.P. PKE-Nefedov: Plasma Crystal Experiments on the ISS // *New Journal of Physics*. – 2003. – Vol. 5. – P. 33.
- [8] Thomas H.M., Morfill G.E., Fortov V.E., Ivlev A.V., Molotkov V.I., Lipaev A.M., Hagl T., Rothermel H., Khrapak S.A., Suetterlin R.K., Rubin-Zuzic M., Petrov O.F., Tokarev V.I., Krikalev S.K. Complex Plasma Laboratory PK-3 Plus on the International Space Station // *New Journal of Physics*. – 2008. – Vol. 10 – P. 033036.
- [9] Pustynnik M.Y., Fink M.A., Nosenko V., Antonova T., Hagl T., Thomas H.M., Zobnin A.V., Lipaev A.M., Usachev A.D., Molotkov V.I., Petrov O.F., Fortov V.E., Rau C., Deysenroth C., Albrecht S., Kretschmer M., Thoma M.H., Morfill G.E., Seurig R., Stettner A., Alyamovskaya V.A., Orr A., Kufner E., Lavrenko E.G., Padalka G.I., Serova E.O., Samokutyayev A.M., Christoforetti S. Plasmakristall-4: New Complex (Dusty) Plasma Laboratory on Board the International Space Station // *Review of Scientific Instruments*. – 2016. – Vol. 87. – No 9. – P. 093505.
- [10] Zobnin A. V., Usachev A. D., Lipaev A. M., Petrov O. F., Fortov V. E., Pustynnik M. Y., Thomas H. M., Fink M. A., Thoma M. H., Padalka G. I. Transverse Ionization Instability of the Elongated Dust Cloud in the Gas Discharge Uniform Positive Column Under Microgravity Conditions // *Journal of Physics Conference Series: XXXI International Conference on Equations of State for Matter (Elbrus 2016)*. – 2016. – Vol. 774. – P. 012174.
- [11] Usachev A.D., Zobnin A.V., A V Shonenkov, Lipaev A.M., Petrov O.F., Fortov V.E., Pustynnik M.Y., Fink M.A., Thoma M.H., Thomas H.M. and Padalka G.I. Influence of Dust Particles on the Neon Spectral Line Intensities at the Uniform Positive Column of dc Discharge at the Space Apparatus «Plasma Kristall-4» // *Journal of Physics Conference Series: XXXI International Conference on Equations of State for Matter (Elbrus 2017)*. – 2018. – Vol. 946. – P. 012143.

Fortov Vladimir Yevgenievich – Doctor of Physical and Mathematical Sciences, Professor, Member of the RAS, Federal State Budgetary Institution of Science “Joint Institute for High Temperatures of the Russian Academy of Sciences”

E-mail:

Petrov Oleg Fedorovich - Doctor of Physical and Mathematical Sciences, Professor, Member of the RAS, Federal State Budgetary Institution of Science “Joint Institute for High Temperatures of the Russian Academy of Sciences”

E-mail:

Usachev A.D. - Candidate of Physical and Mathematical Sciences, Federal State Budgetary Institution of Science “Joint Institute for High Temperatures of the Russian Academy of Sciences”

E-mail:

Lipaev Andrey Mikhailovich - Candidate of Physical and Mathematical Sciences, Federal State Budgetary Institution of Science “Joint Institute for High Temperatures of the Russian Academy of Sciences”

E-mail:

Zobnin A.V. - Candidate of Physical and Mathematical Sciences, Federal State Budgetary Institution of Science “Joint Institute for High Temperatures of the Russian Academy of Sciences”

E-mail:

Molotkov Vladimir Ivanovich - Candidate of Technical Sciences, Federal State Budgetary Institution of

Science “Joint Institute for High Temperatures of the Russian Academy of Sciences”

E-mail:

Pustynnik M.Yu. - Candidate of Physical and Mathematical Sciences, Complex plasma laboratory of the German Space Agency

E-mail:

Thomas Hubertus M. – Ph.D., Complex plasma laboratory of the German Space Agency

E-mail:

Thoma M.H. – Ph.D., Justus Liebig University of Giessen

E-mail:

Serova Yelena Olegovna – Hero of the Russian Federation, Pilot-Cosmonaut of the RF

E-mail:

Samokutyayev Aleksandr Mikhailovich – Hero of the Russian Federation, Pilot-Cosmonaut of the RF, Deputy Commander of the Cosmonaut corps, FSBO “Gagarin R&T CTC”

E-mail:

Padalka Gennady Ivanovich – Hero of the Russian Federation, Pilot-Cosmonaut of the RF

E-mail:

Kononenko Oleg Dmitriyevich – Hero of the Russian Federation, Pilot-Cosmonaut of the RF, Commander of the Cosmonaut corps, FSBO “Gagarin R&T CTC”

E-mail:

Ovchinin Aleksey Nikolayevich – Hero of the Russian Federation, Pilot-Cosmonaut of the RF, FSBO “Gagarin R&T CTC”

E-mail:

Ivanishin Anatoly Alekseyevich - Hero of the Russian Federation, Pilot-Cosmonaut of the RF, FSBO “Gagarin R&T CTC”

E-mail:

Novitsky Oleg Viktorovich - Hero of the Russian Federation, Pilot-Cosmonaut of the RF, FSBO “Gagarin R&T CTC”

E-mail:

Cristoforetti Camantha – Astronaut, European Space Agency

E-mail: