
Crew and spacecraft shielding in outer space

© A.G. Rebeko

Akmeon LLC, Moscow, 117588, Russia

Manned astronautics in deep space is impossible without reliable protection from solar and galactic radiation. We consider the types of radiation found in interplanetary space. We arrive at the conclusion that protection from high-energy charged particles is highly relevant; we then describe the shielding methods available. We suggest an optimum, the most lightweight, type of protection, in the form of an electrostatic shield that is also capable of protecting the spacecraft from small meteoroid particles.

Keywords: *space radiation, charged particles, high energy, meteoroid hazard, magnetic shielding, electrostatic shielding.*

REFERENCES

- [1] Zelentsov V.V. *Nauka i obrazovanie — Science and Education*, 2015, no. 6. Available at: <http://technomag.bmstu.ru/doc/778339.html> (accessed 01 December 2015).
 - [2] Malkin A.I. Novaya kontseptsiya zashchity kosmicheskikh apparatov ot mikro-meteoroidov i orbitalnogo musora [A new concept of spacecraft protection from micrometeoroids and orbital debris]. *Doklady Akademii nauk* [Proc. of the Russian Academy of Sciences], 2011, vol. 436, no. 4, pp. 470–473.
 - [3] *Kosmicheskie apparaty* [Spacecraft]. Moscow, Voennoe Izdatelstvo Publ., 1983, 319 p.
 - [4] Koroteev A.S., ed. *Pilotiruemaya ekspeditsiya na Mars* [Manned expedition to Mars]. Moscow, Tsiolkovsky Russian Academy of Cosmonautics Publ., 2006, 320 p.
 - [5] O'Callaghan J. Nautilus X: The multi-purpose NASA spacecraft that could take humans to the Moon and beyond. *Space Answers*. 14 January 2014. Available at: <http://www.spaceanswers.com/futuretech/nautilus-x-the-multi-purpose-nasa-spacecraft-that-could-take-humans-to-the-moon-and-beyond/> (accessed 01 December 2015).
 - [6] Ginzburg V.L. *Teoreticheskaya fizika i astrofizika* [Theoretical physics and astrophysics]. Moscow, Nauka Publ., 1980, 553 p.
 - [7] Konstantinovskaya L.V. *Solnechnaya aktivnost* [Astronomy. Solar activity]. Available at: <http://sun.jfo.ru/236976.html> (accessed 01 December 2015).
 - [8] Kuznetsov S.N., Kurt V.G., Myagkova I.N., Yushkov B.Yu., Kudela K.N. *Gamma-izluchenie i neytrony solnechnykh vspyshek, zaregistrovannyye priborom SONG v 2001–2004 gg* [Solar flare gamma radiation and neutrons detected by the SONG instrument in 2001-2004]. Skobel'syn Institute of Nuclear Physics, Lomonosov Moscow State University. Available at: http://www.kosmofizika.ru/sinp/solar_gamma.htm (accessed 01 December 2015).
 - [9] Miroshnichenko L.I. *Fizika kosmosa* [Outer space physics]. Available at: <http://www.astronet.ru/db/author/11352> (accessed 01 December 2015).
 - [10] Parker Yu. *V mire nauki — In the World of Science*, 2006, no. 6, pp. 14–20.
 - [11] *Spacecraft Shielding Documents*. Available at: <https://engineering.dartmouth.edu/~d76205x/research/Shielding/#NULL> (accessed 01 December 2015).
 - [12] Burger W.J. Active Magnetic Shielding for Long Duration Manned Space Missions. *6th IAASS Conference, Session 33 Safety Design*. Available at:
-

http://iaassconference2013.space-safety.org/wp-content/uploads/sites/26/2013/06/1000_Burger.pdf (accessed 01 December 2015).

- [13] Rebeko A.G. (RU) *Sposob zashchity ot zaryazhennykh chastits kosmicheskoy radiatsii* [A method of shielding against charged space radiation particles]. Patent RU 2406661, 2010, bulletin no. 35, 7 p.
- [14] Umanskiy S.P. *Zemlya i Vselennaya — The Earth and The Universe*, 1994, no. 6, pp. 22–31.
- [15] Mewaldt R.A. *Cosmic Rays. Macmillan Encyclopaedia of Physics in 1996*. Available at: http://www.srl.caltech.edu/personnel/dick/cos_encyc.html (accessed 01 December 2015).

Rebeko A.G. (b. 1966) graduated from Lomonosov Moscow State University. Manager, Akmeon LLC. Author of 6 scientific publications. Specialises in physical chemistry, astronautics. e-mail: alex@akmeon.com
