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Galactic Cosmic Rays parameters in deep space at 1.5 a.u: ExoMars TGO results

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Abstract

The dosimetric telescope Liulin-MO [4] for measuring the radiation environment onboard the ExoMars TGO is a module of the Fine Resolution Epithermal Neutron Detector (FREND) [3]. It was powered on 22.04.2016 and since then works aboard ExoMars TGO during all periods when no spacecraft maneuvers or aerobreaking were performed. Data taken during TGO cruise to Mars and on high elliptic Mars capture orbit refer to the declining of the 24th Solar cycle and those on TGO science orbit – from April 2018 till present – to the transition to the 25th Solar cycle. Due to the combination of solar activity and working intervals only GCR fluxes were observed. Here we present data for GCL fluxes and doses in Si, measured in the interplanetary space or recalculated for deep space at 1.5 a.u based on measurements in Mars orbit.

1. Introduction

Manned flights to the planets of the Solar system, particularly to the Moon and Mars, are already a near future of the astronautics. The radiation risk appears to be one of the basic factors in planning and designing the exploratory missions. Galactic cosmic rays (GCR) represent a continuous radiation source and they are the most penetrating among the major types of ionizing radiation. The distribution of GCR is believed to be isotropic throughout the interstellar and interplanetary space. Their intensity anti correlates with the solar cycle.

The existing models of GCR need a continuous benchmarking with experimental data. Here we present data about GCR fluxes and doses in the interplanetary space for distances between 1 and 1.5 a,u in the declining of 24th solar cycle and at 1.5 a.u during the present minimum of solar activity base on measurements by the Liulin-MO dosimeter aboard TGO [4].

2. Data and method

Liulin-MO contains two dosimetric telescopes - A&B, and C&D arranged at two perpendicular directions [4]. The fluxes and doses measured in both directions differ by ~5%, due to the different shielding of the surrounding materials.

The FREND dosimeter Liulin-MO was powered on 22.04.2016 and since then works aboard ExoMars TGO during all periods when no spacecraft maneuvers or aerobreaking were performed. Due to the combination of solar activity and working intervals only GCR fluxes were observed. On 19.10.2016 TGO was inserted into Mars high elliptic orbit with apocenter of 98 000 km, pericenter reaching 230 km, 0^0 inclination to the equator, 4.2 days orbit period (MCO1). Liulin-MO worked continuously on this orbit till 17.01.2017 when maneuvers for TGO insertion in lower Mars orbit – Mars capture orbit 2 (MCO2) begun. Data on this high elliptic orbit gave us the possibility to evaluate the contribution of Mars albedo particles to the measured fluxes and doses. The effect of Mars shadowing the particle flux is observed at altitudes less about 3000 km. This effect can be calculated from pure geometrical consideration. Recalculated parameters for deep space using the obtained coefficients exhibited an excess in comparison with the measured fluxes and doses away from the planet. This excess is interpreted to be due to the Mars albedo particles and was evaluated to be ~10%.

In TGO science orbit Liulin-MO nominal orientation is with both telescopes of the instrument looking perpendicularly to the nadir to Mars. The presented in Table 1 deep space data for this period are preliminary, calculated from 3-months averages for direction C&D (as more representative) using the coefficients for the nominal orientation.

Table 1. Flux and dose rate in Si D(Si), measured and calculated for deep space

Time frame TGO phase	Measured parameters		Deep space parameters	
	Flux $cm^{-2}.s^{-1}$	D(Si)) $\mu Gy\ d^{-1}$	Flux $cm^{-2}.s^{-1}$	D(Si)) $\mu Gy\ d^{-1}$
22.04 – 15.09. 2016 Cruise	3.29	390	3.29	390
1.11.2016–17.01.2017 MCO1	3.42	422	3.42	422
24.02– 7.03.2017 MCO2	3.43	425	3.43	425
01.05-31.07.2018 Science Phase	3.1	359	3.52	438
01.08-31.10.2018 Science Phase	3.12	360	3.54	439
01.11.2018-31.01.2019 Science Phase	3.16	360	3.59	439
01.02. -01.05.2019 Science Phase	3.2	368	3.63	448

3. Comparison with models

We compare our data with the results calculated using two models: The International Standardization Organization ISO GCR model [1] and the new SINP-2017 (Skobeltsyn Institute of Nuclear Physics) model [2]. The results are shown in Fig. 1. ISO model gives a better approximation with the experimental dose rates and 2016 – 2017 fluxes, while the experimental fluxes in 2018 are near the SINP-2017 calculations.

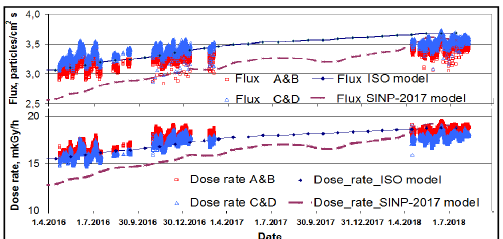

Figure 1: Comparison of experimental and extrapolated Liulin-MO data with fluxes and dose rates calculated by ISO and SINP-2017 models.

4. Summary and Conclusions

We use data from the FREND dosimeter Liulin-MO aboard ExoMars TGO to investigate GCR fluxes in the interplanetary space: i) during the declining of the 24th Solar cycle measured along TGO transit to Mars and on high elliptic Mars orbits; ii) during the present transition to the 25th Solar cycle measured in Mars circular orbit and extrapolated to deep space at 1.5 a.u. During this period GCR flux increased by 10% and GCR dose rates increased by 15 %. Comparison with calculated parameters using ISO and SINP-2017 models showed that ISO models experimental data quite satisfactory.

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References

[1] ISO 15390:2004. Space environment (natural and artificial) - Galactic cosmic ray model https://www.iso.org/standard/37095.html

[2] Kuznetsov, N.V., Popova, H. and Panasyuk, M.I.,. Empirical model of long-time variations of galactic cosmic ray particle fluxes. J. Geophys. Res. Space Phys. 115, 1463–147

[3] Mitrofanov, I., *et al:* Fine Resolution Epithermal Neutron Detector (FREND) onboard the Trace Gas Orbiter, Space Sci Rev, 214:86, DOI:10.1007/s11214-018-0522-5

[4] Semkova, J., *et al*: Charged particles radiation measurements with Liulin-MO dosimeter of FREND instrument aboard ExoMars Trace Gas Orbiter during the transit and in high elliptic Mars orbit, Icarus 303, pp. 53–66, 2018, DOI:10.1016/j.icarus.2017.12.034.

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