Radiation Environment near Exoplanets

A. Struminsky[1,2*]; A. Sadovski [1,3].

[1]Space research Institute, Moscow, Russia
[2]Moscow Institute of Physics and Technology, Dolgoprudny, Russia
[3]National Research University Higher School of Economics, Moscow, Russia

1. Introduction

Stellar winds and cosmic rays are an important factor, which determines the radiation Earth environment. Several candidates of terrestrial planet were discovered last years and it seems to be essential to clarify radiation conditions near them too. We present estimations of stellar wind parameters based on the Parker model, possible fluxes and fluencies of cosmic rays based on the available data of star's activity and magnetic field for Proxima Centauri and Trappist1.
For atmospheric implications it is interesting to know cosmic ray's flux near extrasolar Earth-like planets at the atmospheric boundary, which is determined by effects in the planetary magnetoshere considered in different papers [1, 3]. Authors of [4] supposed that for such planets the GCR rays flux can be regarded as an isotropic and approximately constant as near the Earth at the magnetospheric boundary, i.e. effects of CR modulation were not considered. However stellar wind velocity and magnetic field as well as an activity of other stars (especially red dwarfs) might be much higher in comparison with solar values and the modulation of GCR might be stronger.
Stellar cosmic rays (SCR) were considered in many papers [2, 7-8] as an important factor of space weather in a habitable zone of star. Since the details of SCR spectrum are unknown to model the effect of SCR one may use spectra of well known solar events [2] or average spectrum of solar proton events [8]. Another approach is to base on general physical principles [7] assuming solar-stellar analogies but not on near Earth observations of solar cosmic rays.
Below we use simple equations, which have been proposed in the beginning of space era and may give the necessary answers with accuracy of factor 2--3. The main reason for using this approach is that our knowledge about stellar activities the same as the knowledge of the Sun environments in the beginning of space era in 1950th.

2. Stellar wind and astrospheres

According to model developed by Parker [5] we may estimate a sound speed as a function of the coronal electron temperature, a distance to the critical point and stellar wind velocity . Using the velocity of stellar wind it is possible to estimate its density and derive a coronal temperature for which the critical point of stellar wind is at the coronal boundary , i.e. the maximal temperature for a quite corona.
Knowing the stellar wind parameters and the energy density of local interstellar medium we may estimate the radius of the astrosphere .

3. Galactic and stellar cosmic rays

In paper [6] was suggested that the modulation of GCR by solar wind occurs inside the solar wind shell, which extends uniformly and with spherical symmetry, from a solar distance out to . Stellar wind magnetic field is assumed in a form of the standard Parker spiral. Following [6] we may estimate how the steady state cosmic ray density inside the modulation shell is related to the galactic density outside.
Main modulation parameters are stellar wind magnetic field and velocity. Stellar wind velocities for stars of the same spectral class should not be very different, values of their magnetic fields may differ by one-two orders. As a result effects of GCR modulation might be much stronger and lead to a nearly total absence of GCR fluxes near some exoplanets as shown in Figure 1 for reasonable values near Proxima b. In this case radiation environment near exoplanets would be determined by fluxes of SCR, which should be mainly determined by a level of stellar activity and orbital parameters of the planet.

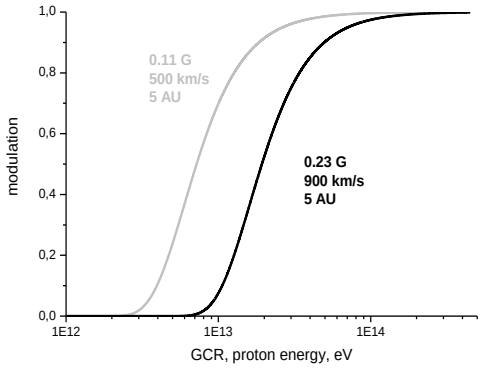

Figure 1: Dependence of modulation coefficient on proton energy near Proxima b

.	n, cm^{-3}		nV/2π, $(cm^{2}s\ st)^{-1}$	
	V=484 km/s, 23AU	V=900 km/s 43 AU	V=484km/s 23 AU	V=900km/s 43 AU
30 MeV	1.2E-8	1.8E-9	0.099	0.025
200 MeV	1.7E-9	2.7E-10	0.013	0.0038

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Table 1: Densities and fluxes of Proxima cosmic rays within the first turn of the Parker spiral

4. Conclusions

In paper we discussed the stellar winds and cosmic rays as an important factor of space weather which determine radiation environment near planets. We used the available parameters and made estimates for stellar winds, possible fluxes and fluencies of galactic and stellar cosmic rays near Proxima b and Trappist1. We obtained that the simple models, which were derived for the Sun in 1950^{th}-1960^{th}, can give the reasonable results for the parameters and conditions on the orbit of exoplanets. Using the available data we showed the level of cosmic rays activity in the habitable zone and influences of the stellar winds on it.

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5. References

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Short Summary

Stellar winds and cosmic rays are an important factor, which determines the radiation environment of planets and exoplanets. We present estimations of stellar wind parameters using the Parker model, possible fluxes and fluencies of cosmic rays based on the available data of star's activity and magnetic field for Proxima Centauri and Trappist1.