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Shock wave acceleration effects in the radiation environment of the early solar system

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Abstract. Observations of active star-forming regions in our Galaxy testify to high in-tensity radiation in those regions, to its high rigidity, and to the possible en-richment of the spectrum with heavier nuclei. All the effects could be caused by acceleration of particles during the propagation of strong shock waves. The peculiar features of irradiation in the shock wave acceleration conditions led to the change of isotope production rates and to the formation of the specific isotopic anomalies in the matter. Such isotopic anomalies could be conserved in the matter of the solar system, which makes it possible to study the radiation environment at the early solar system stage.

Modelling such processes and analysing the isotopic anomalies in chondrites tes-tify, indeed, to the high intensity and rigidity of irradiation, at least, in some condensation reservoirs of the primordial matter. The average radiation conditions over $\leq 10^7$ years before the termination of accretion are characterized by the average integral proton ux $I_p(> 15 MeV) = 1.6210^{19}$,cm^2 (at γ= 2.5 and $\alpha/p = 0.0102$). However, during some extreme processes, accompanied by the strong shock waves, the power-law energy spectrum became atter (up to $\gamma \sim 1.2$), and the integral fluxes $I_p(> E_0)$ were enhanced by 1-2 orders of mag-nitude. It is just the fact that follows from the data on extinct radionuclides in carbonaceous chondrites. It is possible that the matter of the carbonaceous chondrites was condensed in the explosion shell of the last supernova.

The knowledge of the heavy irradiation component at the stage of the active sun is available due to the tracks of VH-group nuclei ($23 < Z < 28$) observed in silicate minerals of some low-metamorphised ordinary chondrites. Several rare grains ($< 1\%$ of $\sim$ 300) are found in which track gradients from single events of irradiation are revealed. As a general feature, the profiles of these gradients are atter (g $\sim$ 0.7–2.0) than those for VH-nuclei of the solar cosmic rays (g $\sim$ 3.0), corresponding to the more rigid irradiation. The absence of superposition of the irradiation events characterizes these tracks, i.e. they were produced due to some local single events of the are pulse type, caused, perhaps, by the reconnection of the magnetic fields in the plasma of the protosolar winds. Obviously, the frequency of the irradiation events was less than the velocity of the matter accretion. The average integral ux of VH-nuclei can be estimated as $I_{VH}(> 15\,\text{MeV/nucl}) \sim 2.610^{16}\,\text{cm}^2$ at $\gamma \sim 2.5$, its increase being possible by 1-2 orders of magnitude if $\gamma \to 1$.