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The numerical simulation of the Interplanetary Radiation Environment induced by Galactic Cosmic Rays

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Galactic cosmic rays (GCRs) are high-energy charged particles originating from the Milky Way and widely distributed throughout the heliosphere. The space radiation environment induced by GCRs significantly impacts spacecraft operations. Numerical modeling provides a cost-effective approach to simulate space radiation environments, thus serves as a critical tool for predicting and evaluating particle radiation conditions. We developed a numerical model by solving cosmic ray transport equations using stochastic differential equations, and determined globally optimal model parameters through Markov Chain Monte Carlo (MCMC) methods. This model successfully reproduces proton and helium energy spectra observed by the PAMELA satellite and AMS-02 experiments during 2006-2017, establishing a database of cosmic ray drift and diffusion parameters under varying solar activity conditions. By comparing modulation parameters between protons and helium nuclei, we verified the consistency of solar modulation model parameters across different nuclear species.

Based on the modulation parameters, we employed an alternating direction implicit (ADI) scheme to solve cosmic ray transport equations, simulating energy spectra for cosmic ray nuclei with charge numbers ranging from 1 (hydrogen) to 26 (iron) throughout the heliosphere from 2006 to 2019. Utilizing these simulation results and incorporating flux-to-dose conversion coefficients published by the International Commission on Radiological Protection (ICRP), we assessed radiation doses induced by galactic cosmic rays during this period. Our calculations reveal spatiotemporal variations in human radiation exposure across the heliosphere.

Collaboration(s)

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