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An Effective and Predictive Model for the Long-Term Variations of Cosmic Rays in the Heliosphere

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Investigating the relationship between cosmic rays and solar activity is of paramount importance in astroparticle and space physics. On one hand, it brings a deeper understanding of the physical mechanisms governing the transport of cosmic rays inside the heliosphere. On the other hand, it plays a crucial role in evaluating radiation exposure and associated risks in space missions. Here, we present our endeavors to establish a new effective and predictive model of solar modulation. Our model incorporates fundamental physics processes of particle transport such as diffusion, drift, convection, and adiabatic cooling to compute the energy spectrum and temporal evolution of cosmic radiation in the inner heliosphere. Calibration and validation of our model are performed using the most recent cosmic-ray data from space-based detectors, such as AMS-02 on the International Space Station, along with multichannel observations of solar activity and interplanetary parameters. This comprehensive model not only demonstrates good results in reproducing observations but also showcases its potential in space radiation monitoring and forecasting. By providing valuable insights for evaluating exposure in future space missions across different regions in the heliosphere, our model is under continuous evolution as new data, such as from AMS-02, become available. By providing a robust framework for understanding cosmic ray variations and their implications for space travel, our research contributes to advancing the safety and effectiveness of space exploration endeavors.

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