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An investigation of Forbush decrease events based on a time-dependent cosmic ray SDE transport model

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A three-dimensional (3D) diffusion-barrier-type model is constructed for producing Forbush decreases (Fds) in the heliosphere. It is based on reduced diffusion inside these barriers, which is incorporated into a Stochastic Differential Equation (SDE) based time-dependent, cosmic ray transport model. This 3D numerical model for simulating Fds is built for and applied to a period of relatively quiet solar activity. We find the following results: (1) Both the latitudinal and longitudinal extent of the barrier have relatively less effects on Fd profiles than its radial extent and the level of decreased diffusion inside the disturbance. (2) The magnitude of a Fd overall decreases with heliocentric radial distance, and it exhibits additionally an oscillating pattern as radial distance increases, which coincides well with the wavy profile of the heliospheric current sheet (HCS). (3) The rotational motion of this HCS causes the relative location from the observation point to the HCS to vary, so that a periodic pattern appears in the cosmic ray intensity at the observing location. Correspondingly, the magnitude and recovery time of Fds change so that the recovering part of the Fd profile contains clear 12-13 day oscillations. Additionally, since the PAMELA and AMS-02 missions have observed Fds in the cosmic ray electron intensity, it is worthwhile to develop a dedicated numerical model for electron Fds. This is done using a new local interstellar spectrum for galactic electrons, and utilizing a different diffusion model for electrons than for protons. Because of the difference in charge and mass, this model enables us to study how protons and electrons behave differently during a single Fd event. These differences, caused by what is assumed for particle drift and diffusion theory, can now be valuated with the help of the mentioned precise observational data.

Primary authors: LUO, Xi (1. North West University, Potchefstroom, South Africa 2. National Space Science Centre, Chinese Academy of Sciences, Beijing, China); POTGIETER, Marthinus (North-West Uiversity)

Presenter: LUO, Xi (1. North West University, Potchefstroom, South Africa 2. National Space Science Centre, Chinese Academy of Sciences, Beijing, China)

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