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On the transport of solar energetic protons near and within a corotating interaction region

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When solar energetic particles (SEPs) escape their acceleration site, they propagate through our solar system, guided by the interplanetary magnetic field (IMF). Upon impacting a satellite, SEPs upset the microelectronics and software on board, leading in some cases to a temporary or permanent failure of the satellite.This highlights the importance of developing models capable of explaining and predicting the characteristics of SEP events.

In this work we study how the interplanetary transport of SEPs is affected by the presence of large-scale plasma structures perturbing a nominal solar wind configuration. Specifically, we focus on the effects of having a fast solar wind source near the solar equator, producing a corotating interaction region (CIR) at low heliographic latitudes. Such a structure affects the IMF, and as a consequence it alters the SEP trajectories. In addition, such CIR is bounded by two shock waves that are able to augment the energy of SEPs through first order Fermi acceleration. We study these effects by coupling a three-dimensional SEP transport model to the heliospheric model, EUHFORIA. The latter model solves the ideal magnetohydrodynamic (MHD) equations, providing realistic solar wind configuration in the heliosphere. This solar wind is then used by our particle transport model to solve the focused transport equation in a stochastic manner, thereby providing SEP distributions in the entire heliosphere. In particular, we look at how the SEP peak-intensity varies along a set of pre-selected magnetic field lines that are residing in varying solar wind conditions. In addition, we illustrate how the 3D structure of the corotating interaction region deforms the original injection region substantially. Finally, we have also explored the efficiency of the CIR pair of shocks at accelerating particles by injecting a seed population of 50 keV protons in the upstream region of both the forward and reverse shock waves. We obtain that the reverse shock accelerates these protons up to 2 MeV in $\sim$50 hours, whereas the forward shock needs˜95 hours to accelerate them to $\sim$400 keV.