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Neutralized solar energetic particles in the inner heliosphere: a parameter study

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The large fluxes of solar energetic particles (SEPs) in Gradual Events, dominated by protons, are believed to be produced by the acceleration of shocks driven by coronal mass ejections (CMEs). As SEPs propagate in the lower corona, there is a chance for them to be neutralized via the charge exchange and/or recombination processes and become energetic neutral atoms (ENAs). These ENAs retain the velocity of their parent SEPs and propagate in straight lines without the influence of the interplanetary magnetic field, and therefore might potentially serve as a new window to observe the particle acceleration processes in the solar corona. STEREO/Low Energy Telescope reported the first probable observation of hydrogen ENAs between 1.6 MeV - 5 MeV from the Sun prior to an X-class flare/CME [Mewaldt et al., 2009]. While such observations were somehow controversial, Wang et al. [2014] simulated the neutralization of solar energetic protons in the corona lower than 40 R_S, and the result agreed with the STEREO observation. In this work, we further developed a production model of the ENA near the sun together with a transport model toward the inner planets, and explore the dependences of the ENA characteristics against the model parameters. These parameters include the angular width of the CME, its propagation direction with respect to the Sun-observer line, the propagation speed, the particle density in the corona, the abundances of O^{6+} and C^{4+}, and the reaction rate of electron impact ionization in the loss of ENAs, and the heliospheric distance of the observer. The calculated ENA flux shows that at lower energy the expected ENA flux depends most sensitively on the CME apex angle and the CME propagation direction. At higher energy the dependence on the coronal density is more prominent.

References

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