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Three-dimensional Simulations of the Inhomogeneous Low Solar Wind

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In the near future, the Parker Solar Probe will put theories about the dynamics and nature of the transition between the solar corona and the solar wind to stringent tests. The most popular mechanism aimed to explain the dynamics of the nascent solar wind, including its heating and acceleration, is magnetohydrodynamic (MHD) turbulence. Most of the previous models focused on nonlinear cascade induced by interactions of outgoing Alfvén waves and their reflections, ignoring effects that might be related to perpendicular structuring of the solar coronal plasma,
despite overwhelming evidence for it. In this paper, for the first time, we analyze through 3D MHD numerical simulations the dynamics of the perpendicularly structured solar corona and solar wind, from the low corona to 15 Rs. We find that background structuring has a strong effect on the evolution of MHD turbulence, on much faster timescales than in the perpendicularly homogeneous case. On timescales shorter than nonlinear times, linear effects related to phase mixing result in a 1/f perpendicular energy spectrum. As the turbulent cascade develops, we observe a perpendicular (parallel) energy spectrum with a power-law index of −3/2 or −5/3 (−2), a steeper perpendicular magnetic field than velocity spectrum, and a strong build-up of negative residual energy. We conclude that the turbulence is most probably generated by the self-cascade of the driven transverse kink waves, referred to previously as "uniturbulence,"which might represent the dominant nonlinear energy cascade channel in the pristine solar wind.

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