CHALLENGES FOR AN AB INITIO THEORY OF COSMIC RAY MODULATION

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Recent efforts to improve and complete modulation theory are described, emphasizing factors that arise in attempts to understand the diffusion tensor based upon turbulence theory and the theory of charged particle scattering. Direct numerical solutions of the transport equations are used to illustrate several sensitive factors affecting modulation which are difficult to understand either observationally or physically. First, the nature of perpendicular diffusion is still poorly understood. We introduce a new perpendicular diffusion formalism that can smoothly vary between the field line random walk limit and a recent treatment based upon the Taylor--Green--Kubo equation. Second, this new perpendicular diffusion coefficient is sensitive to an outer scale of turbulence, the ``ultrascale," that we know almost nothing about. Third, the radial variation of the ordinary correlation coefficient is still poorly characterized, in part owing to the uncertain impact of pickup-driven turbulence in the outer heliosphere. These three factors encompass a very diverse set of possible solutions of the modulation equation, only a small part of which even remotely resembles available observations.
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