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Particle Acceleration Downstream of Dispersive Shock Waves in the Solar Wind

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The solar wind in the heliosheath beyond the termination shock (TS) is a non-equilibrium collisionless plasma consisting of thermal solar wind ions, suprathermal pickup ions (PUI) and electrons. Since the thermalization time scale is much larger than the convection time scale, and the convection time scale is much larger than the isotropization time scale of PUI, the three-fluid description of the heliosheath plasma is a reasonable approximation. In this presentation, we briefly review the theory of dispersive shock waves in multi-ion non-equilibrium plasma. In such plasma, two fast magnetosonic wave modes exist: the high-frequency fast mode that propagates mainly in the PUI and the low-frequency fast mode that propagates in the thermal solar wind ions [Zieger et al., 2015]. Both of these wave modes are dispersive on fluid scale. Recently we have shown that the TS crossing observed by Voyager 2 is a subcritical quasi-stationary dispersive shock wave or oscilliton, which appears as a trailing wave train downstream the TS [Zieger et al., 2015]. Here we present high-resolution three-fluid MHD simulations of nonlinear magnetosonic waves at the TS and in the heliosheath up to 8 AU downstream of the TS. Downstream propagating nonlinear PUI waves grow until they steepen into PUI shocklets (thin current sheets) in the heliosheath. We show that upstream-to-downstream transmissions across a number of forward PUI shocklets can efficiently accelerate both ions and electrons through the shock drift acceleration mechanism deep in the heliosheath, which is a potential mechanism of anomalous cosmic ray (ACR) acceleration as well. The relative energy gain of accelerated particles depends only on the compression ratio of the shocklets, which results in a power law velocity distribution. Our theoretical results are also applicable to particle acceleration downstream of low-Mach-number subcritical interplanetary shocks at 1 AU.