Modeling the Outer Heliosphere with Variable Inner Boundary Conditions

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The outer heliosphere is a dynamic region characterized by the perpetual interaction between the solar wind and the interstellar medium. Having accomplished the original mission to Pluto in 2015 and currently exploring the Kuiper Belt, the New Horizons (NH) spacecraft is fast approaching the heliospheric termination shock (TS), trailing only the Voyager 1 and 2 spacecraft that are probing the very local interstellar medium. We model the three-dimensional (3D), time-dependent solar wind flow to the outer heliosphere using the Multi-Scale Fluid-Kinetic Simulation Suite (MS-FLUKSS) software, which, in addition to the thermal solar wind plasma, accounts for charge exchange between the solar wind ions and interstellar neutral atoms and treats nonthermal ions (i.e., pickup ions) born during this process as a separate fluid. Additionally, MS-FLUKSS allows us to model the transport of turbulence generated by pickup ions in the supersonic solar wind. Using OMNI data as time-dependent inner boundary conditions at 1 AU to solve the Reynolds-averaged MHD equations, we compare the 3D simulation results with in situ observations by an array of NASA spacecraft, such as Pioneer, Voyager, Ulysses, and NH, over five solar cycles. Furthermore, using the same inner boundary conditions to solve the multi-fluid MHD equations, we extend the solar wind flow past the TS to simulate the shocks and pressure waves propagating outward into the very local interstellar medium. This model also allows us to predict when NH is most likely to cross the TS into the heliosheath.

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