The Interaction of the Solar Wind with the Interstellar Medium

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The presence of the interplanetary magnetic field and current sheet and the interstellar magnetic field render the interaction of the solar wind with the local interstellar medium intrinsically 3D. The inclusion of magnetic fields into the problem is therefore challenging from a simulation perspective. Furthermore, the solar wind is itself intrinsically time-dependent on a range of time scales and one has to ideally model the interaction as time variable. Finally, to further complicate matters, interstellar neutral gas, primarily H, is coupled to both LISM and interplanetary plasma through charge exchange and it has been shown in the context of simpler 2D models that neutral H can modify the global structure of the heliosphere profoundly. We discuss here the extension of earlier 2D models of the solar wind-LISM interaction to include interplanetary and interstellar magnetic fields, i.e., modeling the 3D heliosphere. We will demonstrate the profoundly important role that neutral H continues to play in determining the structure of the global heliosphere, and the corresponding back-reaction on the neutral H distribution. This will be addressed in the context of both multi-fluid and kinetic models that have been developed by our group. Observational implications of the neutral H distribution will be discussed briefly. The time-dependence of the heliosphere will also be discussed from the perspective of the response of the termination shock to interplanetary disturbances. Finally, we will discuss the origin of energetic neutral atoms using an approach based on a kappa distribution description of interplanetary plasma, showing how the ENA distributions can be used to investigate global heliospheric structure, plasma properties downstream of the termination shock, and the time dependence of the heliospheric boundaries.