

MHD Modeling of the Outer Heliosphere: Achievements and Challenges

N.V. Pogorelov (1), G.P. Zank (1), and T. Ogino (2)

(1) Institute of Geophysics and Planetary Physics, University of California, Riverside, USA (nikolaip@ucr.edu, zank@ucr.edu), (2) Solar-Terrestrial Environment Laboratory, Nagoya University, Japan

Progress and challenges are discussed in modeling the solar wind interaction with the local interstellar medium (LISM) for different solar wind (SW) and space environment conditions. It is shown that charge exchange between plasma particles and interstellar neutrals is of major importance not only for the scale of the termination shock and the heliopause, but also for various asymmetries observed by the Voyager 1 and 2 spacecrafts and SOHO satellite. In essence, neutral atoms symmetrize the heliosphere, as compared with solutions based on entirely MHD models of the SW–LISM interface. This is applicable both to east-west asymmetries of the termination shock that result in transverse streaming anisotropies in fluxes of energetic charged particles, observed by Voyager 1, and to north-south asymmetries that may explain similar anisotropies being observed now by Voyager 2 in the southern hemisphere. It is shown that interplanetary magnetic field lines do intersect the termination shock multiple times for all possible orientations of the interstellar magnetic field with respect to Sun’s magnetic axis and the LISM velocity vector. However, only certain orientations and magnitudes of the ISMF vector are capable of explaining the data observed.

Physical reasons are analyzed that lead to deflection of the interstellar neutral hydrogen flow from the direction of propagation of neutral helium in the inner heliosheath. On the basis of numerical simulations, possibilities are investigated for deriving the orientation of the interstellar magnetic field as a function of the deflection angle. Parameters are determined that affect the divergence between the LISM neutral hydrogen and neutral helium velocity vectors: strength and direction of the interstellar magnetic field, and the density of the neutral hydrogen in the unperturbed LISM. Both fast-mode and slow-mode LISM flow regimes are investigated, all resulting in the termination shock distances to the Sun agreeable with that determined by Voyager 1. Conditions are formulated that might allow us to use the SOHO SWAN experiment on the interstellar neutral hydrogen velocity orientation as an interstellar magnetic field compass.

The effects of the slow-fast solar wind region separation in the context of the Sun’s 11-year activity cycle are investigated. The consequences of a tilt between the Sun’s magnetic and rotational axes are analyzed.