Space Plasmas in the Solar System, including Planetary Magnetospheres (D)
Pickup Ions in the Heliosphere and Beyond (D1.3)
Consider for oral presentation.

THE ROLE OF PICKUP IONS IN THE SOLAR WIND AND ITS INTERACTION WITH THE LOCAL INTERSTELLAR MEDIUM

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The structure and dynamical evolution of the heliosphere, our home in the universe, is governed by a number of fundamental physical processes that define how plasma and magnetic fields of solar origin interact with the local interstellar medium (LISM). The solar plasma is accelerated near the Sun and creates a solar wind (SW), which is collisionless with respect to Coulomb collisions. The SW–LISM interaction creates a heliospheric termination shock (TS) and the heliopause (HP), both observed in situ by the Voyager 1 (V1) and Voyager 2 (V2) spacecraft. The LISM plasma is partially ionized, so charge exchange between ions and atoms plays a major role in the SW–LISM interaction. New populations of neutral atoms are born in the SW and LISM. Some of them propagate far upstream into the LISM and modify it to such an extent that the existence of a bow shock cannot be confirmed knowing the properties of the unperturbed LISM only. In addition, nonthermal (pickup) ions (PUIs) are created. They energetically dominate the SW at large heliocentric distances, create turbulence, affect the properties of the TS and HP, and are further accelerated to create anomalous cosmic rays. PUIs are measured in situ by Ulysses and New Horizons (NH). Charge exchange with PUIs creates energetic neutral atoms (ENAs), which may propagate to near-Earth distances. Fluxes of ENAs were measured in the past by SOHO and Cassini, and have been mapped by the Interstellar Boundary Explorer (IBEX) since 2009. NASA's IMAP mission, scheduled for launch in 2024, will measure ENAs even more accurately. It is crucial to extract the 3-D properties of the heliosphere and LISM from ENA data. Parker Solar Probe is measuring kinetic properties of the SW plasma and

is expected to answer the fundamental questions related to SW acceleration and transport. Most observational data cannot be explained satisfactorily without time-dependent, data-driven models. These investigations require an integrated approach based on the combination of MHD and kinetic scales.

We discuss a systematic approach for acquiring a quantitative understanding of the dynamical heliosphere affected by PUIs. Our heliospheric model comprehensively describes the relevant physical processes and helps interpret spacecraft observations of turbulent plasma in the SW and LISM. Our simulation results along the NH and Voyager trajectories show a good agreement with measurements both for PUIs and thermal plasma. We discuss physical phenomena affecting the measured ENA fluxes and their evolution in time.

Both the charge exchange and PUI transport phenomena are kinetic processes. Shock crossing by a non-Maxwellian, collisionless plasma is a fundamental, unresolved problem of plasma physics. Our kinetic modeling allows us to develop proper boundary conditions at collisional shocks, which are used in our global SW-LISM interaction calculations. Presented results help build a framework for the interpretation of future IMAP observations.