Final Report

on the Activities of the International ISSI Team
"Heliosheath Processes and Structure of the Heliopause: Modeling Energetic Particles, Cosmic Rays, and Magnetic Fields"
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The Voyager 1 and 2 (V1 and V2) spacecraft are the most distant spacecraft which, after over 37 years of historic discoveries are exploring the boundaries of the heliosphere. Launched in October 2008, the Interstellar Boundary Explorer (IBEX) has also started exploring the outermost reaches of the heliosphere, but from an orbit at 1 Astronomical Unit using the measurements of energetic neutral atoms (ENAs) created in the boundary regions separating the heliosphere from the local interstellar medium. Numerical modeling of ions, neutral atoms, and magnetic fields critically benefits from data obtained by these spacecraft. To perform such numerical analysis, the team has developed a new generation of physical models that can adequately describe the distributions of energetic particles, as well as the thermal plasma, in the inner and outer heliosheath. To trigger the international cooperation of theorists, observers, and modelers, we brought together a group of experts who covered all required fields and who had first-hand access to the most recent measurements.

The problems addressed at the two team meetings (January and November 2014) comprised (1) the challenges in the understanding of V1 measurements in the transition region between the heliosphere and the local interstellar medium (LISM) and discrepancies between the V1 and V2 measurements at the same heliocentric distances; (2) the process that creates the IBEX "ribbon" of the enhanced ENA flux and the role of pickup ions (PUIs) in the energy spectrum of ENA fluxes in different energy bands; (3) the structure of the heliopause due to dissipative processes, instabilities, and magnetic reconnection; (4) Galactic and anomalous cosmic ray transport and anisotropy near the heliopause; (5) kinetic (particle-in-cell) modeling of the PUI behavior near the heliospheric termination shock; (6) magnetic field behavior during the heliopause crossing by V1 and analytical models of the LISM magnetic field draping around the heliopause and simulations of the heliotail; (7) ion acceleration due to magnetic reconnection; (8) new models describing the PUI behavior starting from the supersonic solar wind into the inner heliosheath and on the LISM side of the heliopause; (9) using different, remote and in situ, observational data to derive the LISM properties and agreement between them; (10) energetic charged particle acceleration in the heliospheric current sheet in the inner heliosheath; (11) Fokker-Planck models to describe the PUI acceleration and energy transfer from PUIs to thermal solar wind ions through self-generated turbulence; (12) suprathermal charged particle transport and acceleration in multiple contracting and merging flux ropes; and (13) the effect of heavier elements,

especially helium on the SW-LISM interaction as well as related topics that have emerged during extended discussions following various oral presentations. All these interrelated topics were discussed in the context of the global picture of the heliospheric interface.

We have created a team web site http://www.issibern.ch/teams/structureofheliopause, where the project activity is described, including the papers that have resulted from our discussions. So far, 10 papers are listed there, and we expect more to be added in the near future. The team has decided to submit a summary paper to Space Science Reviews because the range of covered topics is sufficiently wide to affect both the heliospheric physics and other areas of space physics. The team efforts, that thanks to the generous support by ISSI took place in the excellently suited ISSI environment, resulted in the attainment of the goals defined in the original proposal, and, thereby, assisted the mission of ISSI as an international organization aimed to provide a multi- and interdisciplinary setting to reach out for new scientific horizons.