Space Sci Rev (2009) 143: 1–3
DOI 10.1007/s11214-008-9426-0

Foreword

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Received: 31 March 2008 / Accepted: 30 July 2008 / Published online: 20 August 2008

For many years, studies of the outer heliosphere and the interstellar medium were two interesting research fields developing in near isolation from each other. Theoreticians knew that interstellar gas pressure provides the outer boundary condition for models of the solar wind, but little was known about the properties of interstellar gas either inside or outside of the heliosphere. There were no *in situ* plasma measurements of the distant solar wind to guide their studies of the outer heliosphere and beyond.

Since the 1980s, this situation has changed dramatically as a consequence of several developments: (i) measurements of pickup ions of the interstellar gas flowing through the heliosphere and direct observations of the neutral helium flow, (ii) first the prediction (in 1991) and then the detection (in 1996) of the hydrogen wall in the heliopause, (iii) the development of kinetic-fluid and multifluid theoretical models of the interaction of the solar wind with interstellar plasma including charge exchange, (iv) studies of local interstellar gas using ultraviolet absorption-line spectroscopy of nearby stars, and (v) plasma and magnetic-field measurements from Voyagers 1 and 2 as they crossed the termination shock. These developments have enriched both research fields enormously and demonstrated their inherent interrelations.

The primary drivers for this abrupt change in our understanding of the outer heliosphere and local interstellar medium (LISM) are the critical data provided by space missions. Launched in 1984, the Active Magnetospheric Particle Tracer Explorer Ion Release Module (AMPTE IRM) carried the SUprathermaL Energy Ionic Charge Analyzer (SULEICA) experiment that enabled the discovery of the interstellar pickup ions. Beginning in 1990 and still operating successfully, Ulysses carries the Solar Wind Ion Composition Experiment (SWICS) instrument that measures elemental charge states and composition in the solar wind and the pickup ions that result from the charge exchange of solar wind protons and ions with incoming neutrals. The Hubble Space Telescope (HST), also launched in 1990, initially carried the Goddard High Resolution Spectrometer (GHRS) and since 1997, the

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Space Telescope Imaging Spectrograph (STIS). Both instruments have measured absorption lines of hydrogen and other elements in the LISM. The Solar and Heliospheric Observatory (SoHO), launched in 1995 and still operating successfully, carries many instruments, including the Solar Wind Anisotropies (SWAN) instrument that measures backscattered-solar Lyman-α radiation that traces the flow of neutral hydrogen in the heliosphere. The Advanced Composition Explorer (ACE), launched in 1997, continues to provide information on solar wind composition and pickup ions. And, we must not forget the intrepid Voyager spacecraft, launched in 1977, that are providing unique information on the plasma and magnetic fields on both sides of the termination shock.

George Gloeckler, to whom this volume is dedicated on the occasion of his seventieth birthday, played a major role in the analysis of data from these space experiments and in our understanding of physical processes in the outer heliosphere and LISM.

The convenors of this ISSI workshop desired a format that would summarize these developments, identify and critically assess the important physical processes, and foster interdisciplinary research. Our specific objectives were to:

- Cross-fertilize the two scientific disciplines by bringing together active researchers with wide expertise in both fields in a setting that provides opportunities for detailed interactions in both the scientific sessions and in informal small groups.
- Discuss the rapidly advancing developments in both theory and observations, mainly due to space experiments.
- Exploit the rich archive of calibrated data and sophisticated theories tested by comparison with observations of nearby interacting plasmas to develop physical insights and models that could be applied to understanding plasma interactions elsewhere in the universe where the data are sparse and compromised by line of sight averages and the theories are less mature and tested.
- Stimulate modelers to test the accuracy of their various numerical codes by computing models with the same input parameters.
- Stimulate the development of broader perspectives.

With these objectives in mind, the convenors formulated a workshop program based on seven questions that the speakers were asked to address:

- What are the dominant physical processes in the termination shock and inner heliosheath?
- What are the three-dimensional shape and structure of the dynamic heliosphere?
- How are the interstellar plasmas and dust located inside and outside of the heliosphere related?
- What are the origin and physical properties of the very local ISM?
- What are the energy and pressure equilibria in the Local Bubble?
- What are the important physical processes in the multiphase interstellar medium located inside the Local Bubble?
- What are the roles that magnetic fields play in the outer heliosphere and Local Bubble?

During the course of the meeting, it became clear that magnetic fields play important roles in most of the phenomena discussed at the workshop. Therefore, the final question may be the most basic of the seven questions to answer.

To place these questions into a broader context, the convenors requested that several speakers give "big picture" talks on the time evolution of the heliosphere, the origin and evolution of the Local Bubble, the ISM beyond the Local Bubble, and challenges in modeling the heliospheric/ISM interface.

New data and more sophisticated theoretical models with predictive power raised new questions and identified those areas where new observations, both remote sensing and *in* *situ* measurements, are needed. For example, the new data from Voyager 1's crossing of the termination shock at 94 AU (on December 16, 2004) and Voyager 2's crossing at 84 AU (on August 30, 2007, conveniently just before the workshop), provided critical data for use in new MHD models for inferring the orientation and strength of the interstellar magnetic field near the Sun.

To place these new data in context, one often needs new terminology, but it is critical not to confuse the nonexperts and even the experts. For example, what is the best name for the partially ionized plasma that surrounds the heliosphere — now that there is evidence that the heliosphere is located just outside of the Local Interstellar Cloud. After much discussion, the participants decided on the term "circum-heliospheric interstellar medium" or CHISM and proposed that this term be used in the future.

Looking to the near future, the participants hoped for the successful launch and operation of the Interstellar Boundary Explorer (IBEX) satellite and the repair of the high-resolution ultraviolet spectrometers on HST/STIS. They also looked forward to the analysis of both new and archival data for use with 3D kinetic MHD models of the solar wind interaction with the CHISM. The rapid increase in the power of modern computers should facilitate calculations with such complex models.

Looking further into the future, the participants saw the need for a fully instrumented space probe that would measure the plasma and magnetic-field properties through the termination shock and heliopause into the bow shock region and beyond into the CHISM, which is unaltered by the Sun's influence.

We conclude by thanking all of those who made this workshop an extraordinary success. We thank the Directors of ISSI for their generous sponsorship and, in particular, Ruedi von Steiger for his advice in planning and editorial matters. We also thank the local organization team led by Brigitte Fasler for its professional work in planning and supporting the workshop. We thank all of the workshop participants for their excellent presentations, insightful discussions, and well-written papers that constitute the legacy of the workshop. Finally, we thank our summary speaker for his excellent summary and insightful comments on all that transpired.