Symposium Plasmas in the Solar System (SYPS)

jointly organized by
the Plasma Physics Division (P) and
the Extraterrestial Physics Division (EP)

Miriam Sinnhuber
Karlsruhe Institute of Technology
Institute for Meteorology and Climate Research
Atmospheric Trace Gases and Remote Sensing
Hermann-von-Helmholtz-Platz 1
76344 Eggenstein-Leopoldshafen
miriam.sinnhuber@kit.edu

Jan Benedikt
Kiel University
Faculty of Mathematics and Natural Sciences
Institute of Experimental and Applied Physics
Leibnizstr. 19
24098 Kiel
benedikt@physik.uni-kiel.de

There are many different types of plasma in our solar system. The natural ones range from the hot, dense thermal plasma in the Sun, with fusion plasma in the Sun's core being the main source of energy, to low-density corona and solar wind, to auroras, partially ionized plasma of the ionosphere and lightnings in the Earth's atmosphere, and in general in the atmospheres of other planets as well. The human-generated plasmas in research and industry are mainly found on the Earth's surface, but there has been more than half a century of research into plasma-based electric propulsion systems for our satellites, thousands of which can now be found in Earth orbit. This symposium "Plasmas in the Solar System" will illustrate this broad spectrum of plasmas with selected examples introducing experimental and theoretical methods for their analysis.

Overview of Invited Talks and Sessions

(Lecture hall ELP 6: HS 4)

Invited Talks

SYPS 1.1	Thu	11:00–11:30	ELP 6: HS 4	**Energetic Particles in the Turbulent Heliosphere** — •Horst Fichtner
SYPS 1.2	Thu	11:30–12:00	ELP 6: HS 4	**Persistent solar wind forcing of the F2-region ionosphere observed at Tromsø** — •Claudia Borries, Pelin Iochem
SYPS 1.3	Thu	12:00–12:30	ELP 6: HS 4	**In-orbit diagnostics for artificial plasmas created by electric propulsion systems: The Heinrich Hertz Satellite Mission** — •Thomas Trottenberg
SYPS 1.4	Thu	12:30–13:00	ELP 6: HS 4	**Plasma-based space propulsion: status and scientific challenges** — •Kristof Holste

Sessions

SYPS 1.1–1.4	Thu	11:00–13:00	ELP 6: HS 4	**Plasmas in the Solar System**

SYPS 1: Plasmas in the Solar System

Time: Thursday 11:00–13:00 Location: ELP 6: HS 4

Invited Talk SYPS 1.1 Thu 11:00 ELP 6: HS 4

Energetic Particles in the Turbulent Heliosphere — •Horst Fichtner — Ruhr-Universitaet Bochum, Institut fuer Theoretische Physik IV

Observations of numerous energetic particle populations in the heliosphere, e.g. solar energetic particles, Jovian electrons, pickup ions, anomalous and Galactic cosmic rays, have - in connection with theoretical and modelling advances - provided tremendous insight into their transport and acceleration in turbulent plasma environments. At the same time the understanding of turbulence and its interaction with thermal and nonthermal plasma populations has progressed. In the talk an overview will be given that reaches from the simulation of (possibly intermittent) turbulence via (possibly anomalous) transport of energetic particles to heliospheric applications. The latter demonstrate the continuously increasing significance of heliospheric physics as a vital link between basic plasma physics and astrophysics.

Invited Talk SYPS 1.2 Thu 11:30 ELP 6: HS 4

Persistent solar wind forcing of the F2-region ionosphere observed at Tromsø — •Claudia Borries and Pelin Iochem — DLR, Institut für Solar-Terrestrische Physik

The state of the high-latitude thermosphere-ionosphere system gets modified by the solar wind passing Earth. The modifications are best visible during storm conditions. During these conditions, large amounts of solar wind energy are ingested into the thermosphere-ionosphere system which cause global changes in thermosphere and ionospheric electron density. This study investigates 22 years of Total Electron Content (TEC) and 15 years of ionosonde data (critical frequency foF2 and height of maximum electron density hmF2) at Tromsø (70°N, 19°E) with a correlation analysis. The ionosphere parameters are correlated with different solar wind parameters observed at the Lagrangean Point L1. The results show that the ionospheric parameters systematically respond with an increase or decrease depending on local time, season and solar cycle. During winter night conditions TEC and foF2 increase with solar wind energy and during summer daytime they decrease with increasing solar wind energy. The summer negative ionospheric response is more intense during solar maximum conditions, while the winter positive ionospheric response is stronger during solar minimum. Cross polar cap plasma convection, particle precipitation and Joule heating are considered to be the main drivers of the electron density changes at Tromsø. Local time, season and solar cycle changes in the background ionosphere-thermosphere conditions lead to different effects of theses driving processes.

Invited Talk SYPS 1.3 Thu 12:00 ELP 6: HS 4

In-orbit diagnostics for artificial plasmas created by electric propulsion systems: The Heinrich Hertz Satellite Mission — •Thomas Trottenberg — Christian-Albrechts-Universität zu Kiel, Kiel, Germany

The Heinrich Hertz Satellite (H2Sat) was launched in July 2023 and is now positioned in a geostationary orbit around the Earth. H2Sat is primarily a technology mission for the exploration of telecommunication techniques, but it is also equipped with a new electric propulsion system, the 'Highly Efficient Multistage Plasma Thruster' (HEMPT), developed in Germany. Propulsion systems, whether chemical or electric, may imply unwanted effects on the spacecraft. In case of plasma-based electric propulsion systems, a secondary plasma is created during the operation of the thruster that surrounds the satellite. To assess its effects on the spacecraft's surface, an Electric Propulsion Plasma Diagnostic Package (EPDP) was developed by a consortium of Kiel University, von Hoerner & Sulger GmbH, and OHB System AG [1]. This presentation will describe the diagnostics and show data from on-ground tests as well as first data from the satellite.

[1] Trottenberg et al., EPJ Techn. Instrum. 8, 16 (2021). https://doi.org/10.1140/epjti/s40485-021-00073-8

Invited Talk SYPS 1.4 Thu 12:30 ELP 6: HS 4

Plasma-based space propulsion: status and scientific challenges — •Kristof Holste — I. Physikalisches Institut, Justus-Liebig-Universität Giessen, Heinrich-Buff-Ring 16, 35392 Giessen, Germany

Ion thrusters have been researched for more than 60 years and have reached a high level of maturity. They are routinely used for a range of orbital manoeuvres, e.g. for station keeping and, for the last ten years, for electric orbit raising (EOR). The latter has led to a new boom in the field of ion propulsion, as EOR has significantly reduced launch costs.

Nevertheless, there are a number of challenges. The amount of available xenon, currently the most important propellant, is limited. The increasing demand can hardly be met with existing resources, so that alternatives must be found.

The talk is dedicated to the search for alternative propellants and discusses some interesting approaches, such as the use of stable hydrocarbons (e.g. diamondoids) or iodine and the concept of air-breathing thruster, which has been under investigation for several years due to the great interest in low-flying satellites.

In addition, the current topic of the standardisation or comparability of measurements will be addressed, i.e. the transfer of measurements during tests on earth to performance in space, which is becoming increasingly important in view of the boom in these thrusters.