EP 1: Planets and small Objects

Time: Monday 10:45–13:00 Location: HSZ/0004

Invited Talk EP 1.1 Mon 10:45 HSZ/0004

A Melting Probe for the Exploration of Subglacial Lakes within the TRIPLE project line — •Mia Giang Do[1], Jan Audehm[1], Clemens Espe[2], Marco Feldmann[2], Gero Francke[2], Fabian Schöttler[2], Dirk Heinen[1], Stefan Kaiser[1], Andreas Nöll[1], Christopher Wiebusch[1], Yuting Ye[1], and Simon Zierke[1] — [1]RWTH Aachen University - Physics Institute III B, Aachen, Germany — [2]GSI - Gesellschaft für Systementwicklung und Instrumentierung mbH, Aachen, Germany

Jupiter's moon Europa is a prime candidate for the search for extraterrestrial life in the solar system. Previous observations suggest the existence of a global ocean beneath the moon's icy shell. To explore the hidden water reservoir, future missions will need to penetrate the massive ice layer. The development of key technologies for such a mission is the subject of the TRIPLE project line (Technologies for Rapid Ice Penetration and Subglacial Lake Exploration) initiated by the German Space Agency at DLR. Within TRIPLE, an electrothermal probe will be used as the carrier system for transporting scientific payloads. A terrestrial analogous demonstration of the system is planned in the Dome C region in Antarctica. With an expected subglacial lake underneath a 4 km thick icy shell, Dome C does not only provide an ideal test site, but also a great challenge for TRIPLE. To fulfill the mission, it is mandatory for the melting probe to be retrievable and capable of releasing and recapturing payloads at the ice-water interface. This talk will focus on the technological challenges of the melting probe and present the latest terrestrial test campaigns.

EP 1.2 Mon 11:15 HSZ/0004

Material properties of matter in Saturn's interior from ab initio simulations — •Martin Preising[1], Martin French[1], Christopher Mankovich[2], Francois Soubiran[3], and Ronald Redmer[1] — [1]Universität Rostock, Rostock, Germany — [2]California Institute of Technology, Pasadena, USA — [3]Commissariat à l'énergie atomique et aux énergies alternatives, Arpajon, France

Calculation of material properties from ab inito simulations along Jupiter [1] and Brown Dwarf adiabats [2] have been subject of earlier studies. However, accurate models of Saturn's interior are still very challenging. A recent study by Mankovich and Fortney on Jupiter and Saturn models was based on a single physical model [3] which predicts a strongly differentiated helium distribution in Saturn's deep interior, resulting in a helium-rich shell above a diffuse core.

We focus on the calculation of material properties of matter at P-T conditions along the Saturn model proposed by Mankovich and Fortney. We present results on thermodynamic and transport properties of a hydrogen-helium-water mixture that closely resembles the element distribution of the Saturn model. We discuss implications of the results on our understanding of Saturn's interior and evolution.

[1] French et al., Astrophys. J. Suppl. Ser., 202, 5 (2012). [2] Becker et al., Astron. J., 156, 149 (2018). [3] Mankovich and Fortney, Astrophys. J., 889, 51 (2020). [4] Monserrat et al., Phys. Rev. Lett., 112, 055504 (2014). [5] Preising and Redmer, Phys. Rev. B, 102, 224107 (2020).

EP 1.3 Mon 11:30 HSZ/0004

The interior and thermo-chemical evolution of Mars — •Ana-Catalina Plesa and Doris Breuer — DLR, Institute of Planetary Research, Germany

The observational data currently available about Mars provide us with the opportunity to study the interior and thermochemical evolution of the planet with unprecedented detail. This includes geological and mineralogical datasets, gravity and topography data, magnetic field data, and most recently, seismic data from the InSight mission. In this talk, we will show what we have already learned about the interior and thermochemical evolution of Mars, and where there are still open (new) questions - especially through the analysis of the new data from InSight - for the geodynamic reconstruction of the Martian interior.

EP 1.4 Mon 11:45 HSZ/0004

On the propagation of linear and nonlinear waves in the Venusian ionosphere — •Horst Fichtner[1], Alaa Fayad[1,2], Samy Salem[1,2], Marian Lazar[1,3], Waled Moslem[1,2], and Sara Morsi[1,2,4] — [1]Institut für Theoretische Physik IV, Ruhr-Universität Bochum, 44780 Bochum, Germany — [2]Department of Physics, Faculty of Science, Port Said University, Port Said 42521, Egypt — [3]Centre for mathematical Plasma Astrophysics, KU Leuven, 3001 Leuven, Belgium — [4]The British University in Egypt, El-Shorouk City, Cairo, Egypt

The ionosphere of Venus represents, partly due to its interaction with the solar wind, a dynamic plasma environment that hosts a variety of plasma waves. These waves play potentially significant roles for the structure of this region, for the atmospheric erosion, or for the transport and acceleration of energetic particles. In the presentation both linear and nonlinear waves are studied within the framework of (multi-species) hydrodynamics and magnetohydrodynamics, which allows, depending on the model assumptions, to analyze their dispersion in a linearizing approach and their nonlinear dynamics using a perturbative approach. Within the hydrodynamic treatment also the ion outflow from the Venusian atmosphere can be investigated.

EP 1.5 Mon 12:00 HSZ/0004

Conformal mapping for the planetary bow shock and magnetopause studies — •Yasuhito Narita[1], Simon Toepfer[2], and Daniel Schmid[1] — [1]Space Research Institute, Austrian Academy of Sciences, Graz, Austria — [2]Institut für Theoretische Physik, Technische Universität Braunschweig, Braunschweig, Germany

The concept of conformal mapping is introduced to the planetary magnetospheric research as a useful tool to characterize the bow shock and magnetopause geometry and to directly compare the in-situ measurements of magnetic field and plasma flow with the theoretical models. Various models of the planetary bow shock and magnetopause can be extended from the real-number expression to the conformal mapping in the complex plane. By doing so, the spatial domains around the bow shock and magnetopause are easily expressed in orthogonal curvilinear coordinates. In particular, the parabolic bow shock and the tail-elongated magnetopause are found to be conformally mapped using only elementary analytic expressions. Conformal mapping opens the door to construct a high-precision steady-state model of the magnetic field and plasma flow in the planetary magnetosheath region by transforming the Kobel-Flueckiger scalar potential, the exact solution of Laplace equation in parabolic magnetosheath coordinates, to arbitrary two-dimensional bow shock and magnetopause shapes. Such a model will significantly ease the interpretation of magnetic field or plasma data in the planetary missions, as one obtains the global picture of bow shock, magnetopause, and magnetosheath from the model either from the measurements or from the given solar wind condition.

EP 1.6 Mon 12:15 HSZ/0004

Mirror Modes in the Hermean Magnetosheath — •Martin Volwerk[1], Charlotte Goetz[2], Daniel Heyner[3], Tomas Karlsson[4], Ferdinand Plaschke[3], Daniel Schmid[1], and Cyril Simon Wedlund[1] — [1]Space Research Institute, Austrian Academy of Sciences, Graz, Austria — [2]Northumbria University, Newcastle upon Tyne, United Kingdom — [3]Institut für Geophysik und extraterrestrische Physik Technische Universität Braunschweig, Germany — [4]Space and Plasma Physics School of Electrical Engineering and Computer Science KTH Royal Institute of Technology Stockholm. Sweden

Mirror modes are quasi-stationary structures in the plasma frame, consisting of a train of magnetic depressions combined with plasma density enhancements. They are created by a temperature asymmetry in the plasma, where the perpendicular temperature (with respect to the magnetic field) is higher than the parallel temperature. These structures are ubiquitous in planetary magnetosheaths, and have been detected at Venus, Earth, Mars, Jupiter and even at comets. Similar structures to mirror modes are magnetic holes, usually born in the solar wind upstream of the shock and can be transported into the magnetosheath (Karlsson et al., 2021). Here we study magnetic field data during the orbital phase of the MESSENGER mission at Mercury to identify mirror mode-like structures with a magnetic-field-only method. Properties of mirror mode structures will be compared to those of isolated magnetic holes observed in the magnetosheath earlier, to investigate if they are related phenomena

EP 1.7 Mon 12:30 HSZ/0004

Deformed bow shock and magnetic depression: Lessons

from BepiColombo's flyby-2 at Mercury — •Daniel Schmid[1], David Fischer[1], Werner Magnes[1], Yasuhito Narita[1], Martin Volwerk[1], Wolfgang Baumjohann[1], Ayako Matsuoka[2], Uli Auster[3], Ingo Richter[3], Daniel Heyner[3], Ferdinand Plaschke[3], and Rumi Nakamura[1] — [1]Istitut für Weltraumforschung (IWF) Graz, Österreichische Akademie der Wissenschaften (OeAW) — [2]World Data Center for Geomagnetism, Kyoto University — [3]Institut für Geophysik und Extraterrestrische Physik, Technische Universität Braunschweig

Understanding Mercury's magnetospheric structure remains a challenge due to the planet's proximity to the Sun. The magnetic field data from BepiColombo's flyby-2 at Mercury in June 2022 allows us to study the magnetosphere and its space environment in-situ. The bow shock crossing analysis reveals that the shock normal direction is significantly deformed during the inbound crossing and is comforting to the steady-state bow shock shape during the outbound crossing. The magnetosphere crossing analysis reveals a short-time magnetic field depression in the midnight sector before the closest approach, indicating either occurrence of a transient event or crossing of a current layer separating the dipolar from the tail-field region. The BepiColombo flyby-2 magnetic field data analysis shows that Mercury's magnetosphere is highly dynamic and identification of transient events from the quasi-steady state of the magnetosphere plays a crucial role in constructing the magnetospheric structure from the magnetic field data.

EP 1.8 Mon 12:45 HSZ/0004

Analysis of IMF penetration into Mercury's Magnetosphere — •Kristin Pump, Daniel Heyner, and Ferdinand Plaschke — TU Braunschweig, IGEP, Mendelssohnstraße 3, 38106 Braunschweig

Mercury is the smallest an innermost planet of our solar system and has a dipole-dominated internal magnetic field that is relatively weak, very axisymmetric and significantly offset towards north. Through the interaction with the solar wind, this field leads to a magnetosphere. Compared to the magnetosphere of Earth, Mercury's magnetosphere is smaller and more dynamic. A semi-empirical magnetospheric model can capture the large-scale magnetospheric structures. Using the residuals between in-situ data and the model prediction we further seek to improve our understanding of the Hermean magnetosphere. To first order the magnetopause completely separates the magnetosphere from the magnetosheath and thus no magnetic field may penetrate this boundary. In reality, the magnetosheath field may diffuse across the very thin boundary within a finite time. Here, we investigate this penetration and compare the different interplanetary field (IMF) components by their ability to enter into Mercury's Magnetosphere. For this, we use in-situ MESSENGER magnetic field data to estimate the IMF for the time frame with the probe located inside the magnetosphere. The amount of penetration is found by least-square fitting to magnetospheric model results. First statistical results indicate that the penetration is stronger under southward IMF conditions.