EP 6: Sun and Heliosphere I

Time: Wednesday 13:45–15:45 Location: KH 01.019

Invited Talk EP 6.1 Wed 13:45 KH 01.019

Simulation of the photosphere and chromospheres of sunspots — •Aswathi Krishnan Kutty, Robert H. Cameron, Damien Przybylski, Tanayveer Bhatia, and Sami K. Solanki — Max Planck Institute for Solar System Research, Justus-von-Liebig-Weg 3, 37077 Goettingen

Sunspots are one of the most prominent features of the solar surface and are characterized by a dark central core called the umbra, which is surrounded by a collection of filamentary structures called the penumbra. The penumbra is on average considerably brighter than the umbra but darker than the surrounding quiet Sun. At the photospheric level, the nearly horizontal Evershed flow is directed outward from the outer edge of the umbra along penumbral filaments. On the other hand, in the chromosphere, the flow is reversed and the plasma flows inwards towards the umbra. Radiative magneto-hydrodynamic (rMHD) codes have simulated sunspots in the upper convection zone and photosphere (Heinemann et al., 2007; Rempel et al., 2009). However, simulations of sunspots that include a realistic treatment of the chromosphere and corona have not yet been performed. The structure and evolution of the chromospheric field will be important in understanding magnetic reconnection and processes that are important for flare initiation. In this talk, I will present the first simulations of sunspots that reach layers above the solar photosphere.

Invited Talk EP 6.2 Wed 14:15 KH 01.019

Dynamics of a solar prominence simulated with MURaM — •Lisa-Marie Zessner, Robert Cameron, Sami Solanki, and Damien Przybylski — Max Planck Institute for Solar System Research, Göttingen, Germany

Solar prominences are cool and dense plasma clouds suspended in the hot solar corona, supported by the solar magnetic field. These complex and dynamic structures exhibit various types of mass motion and exchange mass with the solar surface and the surrounding atmosphere. Understanding the nature and origin of these dynamics is an important part of solar prominence research.

We use the 3D radiative magnetohydrodynamic code MURaM to simulate the formation and properties of solar prominences in a dipped magnetic arcade configuration. The prominence formation process starts by injection of cool and dense plasma seeds from the chromosphere into the corona. These injections are accompanied by photospheric flux cancellation and reconfigurations of the magnetic field above the surface. The subsequent mass build-up of the prominence is a combination of these continued cool injections and condensation of hot plasma. The resulting prominence structure is dynamic, featuring differently oriented structures and drainage to the surface. In this talk, we present the evolution of individual injection events that feed the prominence, as well as the motion and dynamics of the prominence plasma.

EP 6.3 Wed 14:45 KH 01.019

The Current Layer Missing in the Standard Model of Photospheric Flux Cancellation and CME Initiation — •Bernhard Kliem — Institute of Physics and Astronomy, University of Potsdam

Flux cancellation, driven by flows that converge at the polarity inversion line (PIL), is a common process in the evolution of photospheric magnetic flux. The standard model of photospheric flux cancellation predicts the formation and growth of a magnetic flux rope above the PIL, low in the corona (van Ballegooijen & Martens 1989). Consequently, the cancellation process is considered a pathway to CME initiation by magnetohydrodynamic (MHD) instability, which requires a flux rope to exist at the onset point. Recent MHD simulations of flux cancellation additionally reveal the formation of a vertical current layer or sheet between the PIL and the forming flux rope. This allows for CME initiation by tearing of the vertical current layer, which forms a plasmoid (seed flux rope) during the initiation of a subsequent eruption and is known as the reconnection model for CME initiation. MHD simulations of flux cancellation will be presented, which address the initiation of eruption by MHD instability vs. reconnection and its parametric dependence. Some runs reveal the formation of plasmoids in the slow-rise phase, merging with the main forming flux rope. This could be a model of confined precursor flares and can lead to a non-equilibrium state of the main rope prior to its eruption.

EP 6.4 Wed 15:00 KH 01.019

Strongly localized heating in polytropic expanding stellar wind models — •Lukas Westrich[1,2], Bidzina Shergelashvili[1,2,3,4], and Horst Fichtner[1] — [1]Theoretical Physics IV, Ruhr-Universität Bochum, Universitätsstrasse 150, 44780 Bochum, Germany — [2]Centre for Computational Helio Studies, Faculty of Natural Sciences and Medicine, Ilia State University, Cholokashvili Ave. 3/5, 0162 Tbilisi, Georgia — [3]Evgeni Kharadze Georgian National Astrophysical Observatory, M. Kostava street 47/57, 0179 Tbilisi, Georgia — [4]Institut für Weltraumforschung, Österreichische Akademie der Wissenschaften, Schmiedlstrasse 6, 8042 Graz, Austria

In this talk, we present novel polytropic, expanding solar wind models that include a strongly localized heating source. After introducing the (quasi-)discontinuous solar wind models, we discuss the polytropic index and its use as a simplified description of the energy balance in the expanding plasma. In addition to the *background* energy-balance process captured by the polytropic index and for a few solutions a Hollweg type like heat conduction, we introduce a strongly localized heating mechanism - possibly due to acoustic waves - and construct new polytropic stellar wind models, both analytical and numerical. These new stellar wind models may be of particular interest in light of recent Parker Solar Probe observations, which reveal strongly varying wind streams and the presence of acoustic waves close to the Sun.

EP 6.5 Wed 15:15 KH 01.019

Solar wind heat flux with kappa distributions — •Klaus Scherer[1], Marian Lazar[2], Horst Fichtner[1], and Lukas Westrich[1] — [1]Institut für Theoretische Physik, Lehrstuhl IV: Plasma-Astroteilchenphysik, Ruhr-Universität Bochum, D-44780 Bochum, Germany — [2]Centre for mathematical Plasma Astrophysics, Department of Mathematics, KU Leuven, Celestijnenlaan 200B, 3001 Leuven, Belgium

In the collisionless solar wind between 0.3 and 5 au, the proton usually have Maxwellian velocity distributions, while the electron distributions exhibit extended tails in the anti-sunward direction and a (spherical) cut-off towards the Sun. In case such electron distributions are assumed to be Maxwellians the resulting heat flux was modelled and discussed in Hollweg (1974). We apply this approach replacing the Maxwellian by a Kappa distribution, using both the classical standard Kappa distribution (SKD) and the newer regularized Kappa distribution (RKD). In contrast to SKDs, RKDs allow the calculation of the heat flux for any positive value of the kappa parameter. We present (semi-)analytical results and employ them in a one-dimensional hydrodynamic model of the solar wind expansion to show the impact of the distribution function on the magnitude of the heat flux.

EP 6.6 Wed 15:30 KH 01.019

On the complexity of plasma instabilities in the solar wind: Three electron-component formalism of heat-flux instabilities — •Dustin Lee Schröder[1], Marian Lazar[1,2], and Horst Fichtner[1] — [1]Ruhr-Universität Bochum — [2]Katholieke Universiteit Leuven

Despite the fact that electrons observed in-situ in space plasmas have three major components, the quasithermal core, and the suprathermal halo and strahl, the analysis of instabilities triggered by kinetic anisotropies (such as a relative drift of the strahl) generally considers only two of these components. We aim to demonstrate that a realistic modeling, with all three components, is achievable, in the present analysis focusing on heat-flux instabilities. In the absence of particle-particle collisions, these instabilities are responsible for the regularization of the heat flux carried mainly by suprathermal electrons. The velocity distributions of the electron populations are modeled according to in-situ observations, with a Maxwellian core and κ-distributed halo and strahl components. We exploit new advanced numerical codes (DIS-K and ALPS), capable of solving the linear dispersion and stability properties of such plasma systems. The unstable solutions differ significantly from those obtained with simplified models with only two components. The growth rates now predict the excitation and interplay of two unstable modes, whistler heat-flux and/or firehose heat-flux instabilities. The two instabilities are triggered by the two relative drifts, core-strahl and halo-strahl, and may have new consequences in the regularization of the heat-flux.