Numerical Simulation of Hightemperature Plasmas (SYNS)

gemeinsam veranstaltet von den Fachverbänden
Extraterrestrische Physik (EP) und
Plasmaphysik (P)

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Übersicht der Hauptvorträge und Fachsitzungen

(Zahnklinik)

Hauptvorträge

SYNS 1.1	Do	14:00–14:30	HS Biochemie (groß)	**Kinetic Dissipation of Solar Wind Turbulence** — •Gregory G. Howes
SYNS 1.2	Do	14:30–15:00	HS Biochemie (groß)	**Multiscale Simulations of Magnetohydrodynamic Flows** — •Rainer Grauer

Fachsitzungen

SYNS 1.1–1.2	Do	14:00–15:00	HS Biochemie (groß)	**Numerical Simulation I**
SYNS 2.1–2.7	Do	16:00–17:45	HS Biochemie (groß)	**Numerical Simulation II**

SYNS 1: Numerical Simulation I

Zeit: Donnerstag 14:00–15:00 Raum: HS Biochemie (groß)

Hauptvortrag SYNS 1.1 Do 14:00 HS Biochemie (groß)
Kinetic Dissipation of Solar Wind Turbulence — •Gregory G. Howes — University of Iowa, Iowa City, IA, USA

The identification of the key physical mechanisms by which the turbulence in the solar wind is dissipated remains a fundamental unsolved problem in heliospheric physics. I will present a theoretical model of the turbulent cascade from the large scales of energy injection, through the transition to kinetic turbulence at the scale of the ion Larmor radius, down to the electron scales at which the turbulent energy must ultimately be dissipated. Kinetic simulations of the magnetized turbulent cascade in the solar wind at the scale of the ion Larmor radius support the hypothesis that the frequencies of turbulent fluctuations in the solar wind remain well below the ion cyclotron frequency both above and below the ion gyroscale. I will present the first nonlinear kinetic simulations of kinetic Alfven wave turbulence in the dissipation range from the ion to electron Larmor radius scales.

Hauptvortrag SYNS 1.2 Do 14:30 HS Biochemie (groß)
Multiscale Simulations of Magnetohydrodynamic Flows — •Rainer Grauer — Institut für Theoretische Physik I, Ruhr-Universität Bochum

Many problems in magnetized plasmas are inherently multiscale in nature where the small scale dynamics at the limit of the MHD approximation has a major impact on the dynamics on global scales. Prominent examples are magnetic reconnection, filamentation instabilities and turbulence. In most applications, the flow is compressible and should be treated numerically with an appropriate conservative scheme. A common technique to handle the multiscale nature in these flows is the application of block structured adaptive mesh refinement to resolve the small scales without too much effort. In this talk, I will give an overview of various techniques for conservation laws, methods to deal with the div B = 0 problem and ways to treat special complications which arise in adaptive mesh refinement simulations on massive parallel machines (# CPUs > 8.000).

Since the topics mentioned above are not only multiscale but also multiphysics problems, I will give an outlook on the next step for coupling multiscale fluid simulations on global scales with kinetic simulations in nonideal regions.

SYNS 2: Numerical Simulation II

Zeit: Donnerstag 16:00–17:45 Raum: HS Biochemie (groß)

SYNS 2.1 Do 16:00 HS Biochemie (groß)
Microturbulence in Astrophysical and Fusion Plasmas — •Moritz J. Pueschel[1], Thilo Hauff[1], Frank Jenko[1], and Harald Lesch[2] — [1]IPP Garching, Germany — [2]Universitäts-Sternwarte München, Germany

Anomalous (turbulent) transport is the dominant heat transfer causing process in fusion core plasmas. Here, (gyro-)kinetic simulations have yielded good descriptions of multiple features of turbulence. This framework can be applied to astrophysical scales, as well, with no or few modifications. In this work, we employ the gyrokinetic electromagnetic code Gene to calculate turbulent heat fluxes due to plasma microturbulence. These results are then applied to the cooling flow problem where magnetic fields are believed to impair heat exchange between regions of different temperature; microturbulent transport in these systems can exceed conductive values significantly. On the base of gyrokinetic fusion plasma investigations, conclusions are drawn concerning different parameter regimes. In a separate investigation, the behavior and effects of energetic particles in turbulent electromagnetic fields are studied, applying fusion plasma knowledge to the interaction of cosmic particles with the solar wind. The movement of solar and cosmic particles through the solar system is not yet fully understood, and turbulent interactions might play an important role in cross-field transport.

SYNS 2.2 Do 16:15 HS Biochemie (groß)
Numerical simulations of turbulent cascade in solar-flare magnetic reconnection — •Miroslav Bárta[1,2] and Jörg Büchner[1] — [1]Max-Planck-Institut für Sonnensystemforschung, Max-Planck-Str. 2, D–37191 Katlenburg-Lindau, Germany — [2]Astronomical Institute of Czech Academy of Sciences, Fričova Str. 298, CZ–25165 Ondřejov, Czech Republic

The concept of turbulent magnetic reconnection becomes now very attractive in the solar flare research as it can address many open issues in that field. Nevertheless, it has not been explored yet by numerical simulation since it requires a model which spans over a broad scale-range of mutually coupled phenomena. Traditional simulation approaches are not capable to cover a range of scales from the global system dimensions down to the dissipation scale because of limited number of grid points.

A solution could be the development of appropriate recursive numerical algorithm which at different levels of recursion solves the processes in current sheet fragmentation on different spatial and temporal scales. For this sake we suggest a numerical scheme, where the data representing the system under study are stored in a dynamic hierarchically organised data structure (a tree) which should reflect the self-similar properties of the anticipated solution. To some extent such algorithm can be considered as an alternative approach to Adaptive Mesh Refinement (AMR) codes.

SYNS 2.3 Do 16:30 HS Biochemie (groß)
Energy balance of the corona in a 3D MHD numerical model — •Sven Bingert — Kiepenheuer-Institut für Sonnenphsik, Freiburg, Germany

The comparison of forward numerical models to observations is based on the computation of line emissions. To compare emission lines formed in the transition region it is necessary to reproduce the steep gradient. Therefore it is important to use a proper energy balance in the simulations including radiative loss and Spitzer heat conduction. We show results of a 3D MHD numerical model of the solar corona. The heating is ohmic dissipation of a dynamic magnetic field driven by photospheric motions. The direct access to the magnetic field vector allows us to evaluate the spatial and temporal distribution of heating events. The energy equation including the anisotropic heat conduction and its limits in this simulation will be discussed.

SYNS 2.4 Do 16:45 HS Biochemie (groß)
Lagrangian statistics and the phenomenological description of turbulence — •Angela Busse and Wolf-Christian Müller — Max-Planck-Institut für Plasmaphysik, Garching bei München

Various models have been proposed for the phenomenological description of the energy cascade in fully developed MHD turbulence. Based on the nonlinear interaction mechanism underlying the cascade process they can be divided into two main groups: Models of Iroshnikov-Kraichnan type which employ a weak interaction mechanism and the Goldreich-Sridhar phenomenology and its derivatives which propose a strong interaction mechanism. In the Eulerian reference frame it is difficult to distinguish between strong and weak interaction mechanisms since the same scaling laws for the energy spectrum can be derived using different cascade mechanisms. The Lagrangian frequency spectrum however, is sensitive to the time scales involved in the underlying cascade dynamics and different scaling laws in the inertial range are expected for weak and strong interaction mechanisms.

The Lagrangian frequency spectrum has been obtained by tracking fluid particles in direct numerical simulations of incompressible MHD turbulence for both the two- and three-dimensional cases. Results for the macroscopically isotropic MHD case as well as MHD turbulence under the influence of a strong mean magnetic field are presented.

SYNS 2.5 Do 17:00 HS Biochemie (groß)
Transfer analysis of a local surface dynamo — •Jonathan Pietarila Graham, Robert Cameron, and Manfred Schüssler —

Max-Planck-Institut für Sonnensystemforschung, 37191 Katlenburg-Lindau, Germany

We conduct spectral energy transfer analysis of "realistic" simulations of solar magneto-convection and local dynamo action. We determine how far the results of spectral non-locality for incompressible homogeneous MHD small-scale dynamo action carry over to solar conditions of stratification, compressibility, partial ionization and radiative energy transport. Comparison with the results for realistic simulations clarify the similarities and differences between the small-scale turbulent dynamo in idealized systems to the solar local dynamo thus providing a more significant connection between the results of the large body of literature for homogeneous isotropic turbulence to solar applications.

SYNS 2.6 Do 17:15 HS Biochemie (groß)

Nonlinear MHD dynamo simulations in spherical geometry — •Klaus Reuter and Frank Jenko — IPP Garching

The MHD dynamo process is commonly believed to cause cosmic magnetic fields, e.g. in planets, stars, and galaxies. In recent years, several experiments which implement turbulent flows of liquid sodium were performed in order to study dynamo action in the laboratory. We present numerical simulations of a mechanically driven, electrically conducting flow in spherical geometry which consists of two counter-rotating flow cells, similar to the flow realized in the Madison Dynamo Experiment. The aim of our studies is to better understand the influence of turbulence on magnetic field amplification which turned out to be highly detrimental in the actual experiment.

At low Reynolds numbers Re, a hydrodynamic instability gives rise to propagating wave features which can either support or hinder dynamo action, depending on their spatio-temporal properties. Turbulent fluctuations which appear at higher Re strongly inhibit the dynamo process. The critical magnetic Reynolds number $\mathrm{Rm_c}(\mathrm{Re})$ above which magnetic field amplification sets in is discussed.

Finally, it is shown that the turbulent flow allows for subcritical dynamo action. These subcritical dynamo states can either be reached by suddenly reducing Rm below $\mathrm{Rm_c}$, or by applying external finite amplitude magnetic fields. The latter finding may be useful for the dynamo experiment to reach a state of self-excitation.

SYNS 2.7 Do 17:30 HS Biochemie (groß)

Numerical simulation of active regions of the Sun — •Jean Santos and Büchner Jörg — Max-Planck-Institut für Sonnensystemforschung, Max-Planck-Str.2, 37191, Katlenburg-Lindau, Germany

We present first results of the numerical simulation of active regions of the Sun using a computer code in development that takes into account the complex structure of the coronal magnetic field in its relation to the photospheric sources, the inhomogeneity of the strongly structured plasma including the transition region and the coupling of ions to the neutral atoms in the chromosphere. Using this model we started to investigate the evolution of the solar corona above active regions at the surface of the Sun.