P 21: Theory and Modelling II

Zeit: Mittwoch 14:00–16:10 Raum: HZO 50

Hauptvortrag P 21.1 Mi 14:00 HZO 50

Turbulence optimisation in stellarator experiments — •Josefine H. E. Proll[1,2], Benjamin J. Faber[3], Per Helander[1], Samuel A. Lazerson[4], Harry E. Mynick[4], and Pavlos Xanthopoulos[1] — [1]Max-Planck/Princeton Center for Plasma Physics — [2]Max-Planck-Institut für Plasmaphysik, Wendelsteinstr. 1, 17491 Greifswald, Deutschland — [3]HSX Plasma Laboratory, University of Wisconsin-Madison, Madison, WI 53706, USA — [4]Plasma Physics Laboratory, Princeton University, P.O. Box 451 Princeton, New Jersey 08543-0451, USA

Stellarators, the twisted siblings of the axisymmetric fusion experiments called tokamaks, have historically suffered from confining the heat of the plasma insufficiently compared with tokamaks and were therefore considered to be less promising candidates for a fusion reactor. This has changed, however, with the advent of stellarators in which the laminar transport is reduced to levels below that of tokamaks by shaping the magnetic field accordingly. As in tokamaks, the turbulent transport remains as the now dominant transport channel. Recent analytical theory suggests that the large configuration space of stellarators allows for an additional optimisation of the magnetic field to also reduce the turbulent transport. In this talk, the idea behind the turbulence optimisation is explained. We also present how an optimised equilibrium is obtained and how it might differ from the equilibrium field of an already existing device, and we compare experimental turbulence measurements in different configurations of the HSX stellarator in order to test the optimisation procedure.

Fachvortrag P 21.2 Mi 14:30 HZO 50

2D multiscale model for coupling mesoscale drift fluid dynamics and macroscale particle transport in the tokamak plasma edge — •Felix Hasenbeck[1], Dirk Reiser[1], Philippe Ghendrih[2], Yannick Marandet[3], Patrick Tamain[3], and Detlev Reiter[1] — [1]IEK-4 - Plasmaphysik, Forschungszentrum Jülich GmbH, Jülich, Germany — [2]CEA Cadarache, DRFC/SPPF, Saint-Paul-lez-Durance, France — [3]PIIM, CNRS/Université de Provence, Marseille, France

Radial transport in the plasma edge is decisive for the lifetime and performance of a tokamak fusion reactor. While mesoscale drift fluid models allow for detailed assessment of transport processes, they remain computationally expensive for predictions on the reactor scale. So-called macroscale transport codes are less resource-demanding but typically describe radial transport via simplified models with empirical transport coefficients. Here, a multiscale approach is presented which includes the effects of averaged mesoscale dynamics on the macroscale profiles. Its implementation within the B2-ATTEMPT coupled code system for enhanced radial particle transport description is outlined. Simulations of experiments performed at the tokamak TEXTOR show reasonable agreement for profiles of n_e and T_e at the outer midplane with a 5 to 25% level of uncertainty. The poloidal dependence of self-consistently determined profiles of the radial particle diffusion coefficient D reflects the ballooning character of transport. Typical values of D are between 0.3 and 0.9 m^2/s and are within a 10 to 30% range of effective diffusion coefficients employed hitherto in B2-EIRENE simulations with freely adjusted radial diffusivities to match experiments.

P 21.3 Mi 14:55 HZO 50

Longitudinal and transverse structure functions in homogeneous isotropic MHD turbulence — •Jan Friedrich[1], Holger Homann[2], Tobias Schäfer[3], and Rainer Grauer[1] — [1]Theoretische Physik I, Ruhr-Universität, 44780 Bochum, Germany — [2]Laboratoire J.-L. Lagrange, Universite de Nice-Sophia Antipolis, CNRS, France — [3]Department of Mathematics, College of Staten Island, CUNY, USA

We investigate the scaling behaviour of longitudinal and transverse structure functions in homogeneous and isotropic MHD turbulence by means of exact structure function equations as well as numerical simulations of three-dimensional MHD turbulence. A hierarchy of structure function relations is obtained from the basic MHD equations in making use of the tensor calculus introduced by Chandrasekhar [1]. It is found that no fundamental difference between longitudinal and transverse structure functions in the inertial range exists, in contrast to the hydrodynamic case, where transverse structure functions prove to be slightly more intermittent than their longitudinal counterparts [2]. This peculiar behaviour can be attributed to a local alignment between velocity and magnetic field that leads to an effective reduction of pressure contributions.

[1] S. Chandrasekhar, Proc. R. Soc. Lond. A, 204, 1079 (1951)
[2] R. Grauer, H. Homann, J.F. Pinton, NJP, 14:063016 (2012)

P 21.4 Mi 15:10 HZO 50

Particle merging algorithm for PIC codes by using Voronoi tessellation method — •Phuc T. Luu and Alexander Pukhov — Institut für Theoretische Physik I, Heinrich-Heine-Universität, Düsseldorf, Germany

We present the results concerning a novel particle merging algorithm for particle-in-cell codes. Our algorithm is based on the Voronoi tessellation method for partitioning a given simulation cell of n particles into k clusters. Each cluster consists of particles which are close to each other in the phase space. The algorithm is implemented into Virtual Laser Plasma Laboratory (VLPL) code and compared in the case of QED-cascade.

P 21.5 Mi 15:25 HZO 50

Determination of ion mobilities from the ion energy distribution functions — •Tsanko Vaskov Tsankov and Uwe Czarnetzki — Institute for Plasma and Atomic Physics, Ruhr-University Bochum, 44780 Germany

The ion mobilities or, equivalently, the ion-neutral collision frequencies are important input parameters not only for numerical simulations but also for the general understanding of the discharge structure and the ionisation balance. Due to the complex internal structure of both collision partners, the theoretical calculation of the collision characteristics is in this case a cumbersome task and most of the available data comes from drift tube experiments [1]. The ion mobilities in a foreign gas are difficult to obtain even experimentally and such data are scarce.

Here a relation between the ion energy distribution functions at the wall of an inductive discharge and the plasma parameter profiles is derived which allows the determination of ion-neutral collision frequencies. The technique works equally well for ion collisions with the parent gas or with foreign species. Values for several noble gases and their mixtures are obtained and compared with available literature data [1].

[1] E W McDaniel, E A Mason, *The Mobility and Diffusion of Ions in Gases* (John Wiley & Sons, New York, 1973)

P 21.6 Mi 15:40 HZO 50

Adaptive Coupling of Different Plasma Models in Numerical Simulations — •Thomas Trost and Rainer Grauer — Institute for Theoretical Physics I, Ruhr-University Bochum, Germany

Plasmas are complex systems. Depending on the regime, different models are appropriate for describing a certain situation. In most cases of interest, the underlying equations can only be solved numerically and even that can be challenging, for example if kinetic effects in a two- or three-dimensional configuration are studied, as it is done in our project.

Nevertheless, many interesting plasma phenomena, as for example magnetic reconnection, depend on multiscale effects and exhibit a clear spatial separation of different regimes. This can be exploited for gaining significant speedup in numerical simulations by restricting the expensive solution of kinetic equations to the smallest region possible.

We present an algorithmic approach to combine kinetic and fluid models during the runtime of a simulation depending on the local plasma regime in an adaptive way. Subregions of the numerical domain are described with different plasma models and interact through carefully chosen boundary conditions. Furthermore, the kinetic equations are solved on graphic cards in order to obtain further speedup.

We present first examples of our method and compare them to previous results that were obtained with more conventional methods.

P 21.7 Mi 15:55 HZO 50

Untersuchung der Zyklotrondämpfung von L-Moden in PiC Simulationen — •Cedric Schreiner[1,2], Andreas Kempf[3] und Felix Spanier[1] — [1]Center for Space Research, North-West University Potchefstroom, Südafrika — [2]Lehrstuhl für Astronomie, Universität Würzburg — [3]Lehrstuhl für Theoretische Physik IV, Ruhr-Universität Bochum

Plasmawellen werden im Bereich der Zyklotronfrequenzen der geladenen Teilchen im Plasma gedämpft. Die Dämpfungsrate, die die Zeitskala dieses Prozesses beschreibt, ist analytisch nur schwer zugänglich, was eine theoretische Beschreibung erschwert.

Zahlreiche Vereinfachungen und Näherungen sind zwar vorhanden, lassen aber jeweils nur die Betrachtung einzelner Spezialfälle zu. Einzig das numerische Lösen der exakten Dispersionsfunktion liefert ein vollständiges Bild der Dämpfungsrate in einem weiten Frequenzbereich, ist aber zugleich aufwändig und umständlich.

Mit Hilfe der exakten Dispersionsfunktion der L-Mode wurde eine Parameterstudie durchgeführt, um die Abhängigkeit der Dämpfungsrate von verschiedenen Plasmaparametern (Magnetfeld, Plasmafrequenz, Temperatur) zu untersuchen. Die daraus resultierenden Ergebnisse erlauben eine einfache Abschätzung der Dämpfungsrate mittels einer analytisch lösbaren Funktion in Abhängigkeit der oben genannten Parameter.

Weiterhin wurde das Verhalten von gedämpften Wellen in Particle-in-Cell (PiC) Simulationen analysiert. Es zeigt sich, dass das erwartete Verhalten in PiC Simulationen korrekt reproduziert wird.