P 5: Theory/Modelling I

Time: Tuesday 14:15–15:55 Location: B 302

Topical Talk P 5.1 Tu 14:15 B 302

Evoultion of MHD Turbulence — •Martina Wisniewski[1], Felix Spanier[1], and Ralf Kissmann[2] — [1]Lehrstuhl für Astronomie, University of Würzburg — [2]Department of Physics, University of Helsinki

In this talk we present the results of our turbulence evolution simulations. The plasma starts out from an unperturbed state while a discrete turbulent energy is injected into the system at each time step. The energy of the system increases until reaching convergence. This enables us to study the physics taking place on small time scales where only a few waves are present (e.g. three wave interactions). On intermediate time scales it can be analysed how the full turbulent spectrum evolves and on large time scales the convergency range is analysed. We inject either pure compressible or pure incompressible energy and analyse how the results depend on this driving. We also vary the magnetisation of the system as a second parameter.

These simulations are done on the basis of our three dimensional MHD-code. The MHD-equations are evolved by an second order CWENO solver. The time evolution is simulated by a third order RK-algorithm.

P 5.2 Tu 14:40 B 302

Theory of strongly correlated spherically confined plasmas — •Michael Bonitz[1], Alexei Filinov[1], Patrick Ludwig[1], Hanno Kählert[1], Christian Henning[1], and James W. Dufty[2] — [1]Institut für Theoretische Physik und Astrophysik, Christian-Albrechts-Universität Kiel — [2]Department of Physics, University of Florida, Gainesville (USA)

Charged particles in a spherical confinement potential form Coulomb crystals consisting of concentric shells. This has been observed experimentally in ultracold ions and in dusty plasmas [1]. These systems allow for an analysis of strong correlation effects with an unprecedented accuracy. Moreover they are a test ground for theoretical approaches to strongly coupled systems. In this talk we review recent theoretical results. First we show that the shell structure of these crystals agrees well with first principle computer simulations [2]. Then, theoretical results for the excitation spectrum will be reported [3] and an analytical theory for the density profile [4], the pair correlations and the thermodynamic properties will be presented [5]. Finally, the short-time behavior is discussed with a particular focus on the crystallization dynamics [6].

[1] Arp et al. PRL 93 (2004), [2] Bonitz et al. PRL 96 (2006), [3] Henning et al. PRL 101(2008), [4] Henning et al. PRE 76 (2007), [5] Wrighton et al. PRE, accepted (2009) [6] Kählert et al. PRL, accepted (2009)

P 5.3 Tu 14:55 B 302

Magnetic geometry effects on geodesic acoustic modes — •Robert Hager and Klaus Hallatschek — Max-Planck-Institut für Plasmaphysik, Boltzmannstraße 2, D-85748 Garching, Germany

The approach to the calculation of the GAM group velocity from the radial free energy flux and the total free energy presented in Phys. Plasmas **16**, 072503 (2009) is generalized to up-down asymmetric magnetic geometries. By removing the neoclassical cancellation effects, up-down asymmetry can trigger a non-vanishing group velocity at zero radial wavenumber. Adequate shaping of the plasma allows control of the direction and magnitude of the GAM group velocity, which can be of the order of the magnetic drift velocity or larger. Altering the direction and speed of the GAM propagation might be used to check for a potential influence on the confinement and even on the H-mode.

Taking up recent reports on GAM eigenmodes and the role of GAMs in turbulence saturation, the influence of the magnetic geometry on GAMs and their interaction with turbulence is investigated using numerical two-fluid studies. While preserving the properties of the turbulent modes, the magnetic configuration is varied to study how the GAM spectrum, the structure of GAM eigenmodes, and the ability of GAMs to modulate turbulent transport depend on geometry parameters such as the plasma elongation.

P 5.4 Tu 15:10 B 302

Derivation of a Reynolds stress response functional for zonal flows from numerical studies — •Niels Guertler and Klaus Hallatschek — Max-Planck-Institut für Plasmaphysik, Garching b. M., Germany

Numerical self-consistent ITG-turbulence studies, using the NLET code, show a Reynolds stress driven zonal flow pattern with a characteristic radial scale length. The level of turbulence is affected by both the intensity and the radial structure of the zonal flows. At the same time, the zonal flows are governed by the turbulence generated stress pattern. A feedback loop between turbulence and zonal flows results, which sets up a nearly stationary flow pattern in balance with turbulence. Turbulent states modified with artificial initial flow profiles do always decay into the self-consistent zonal flow pattern and demonstrate the intrinsic nature of its radial scale length and the robustness of the mechanism. Based on wave-kinetic theories, a response functional of the observed flows can be created, which reproduces the stress quantitatively albeit fails to predict the intrinsic flow pattern and its radial scale length. We use synthetic flows to validate and parameterize the analytic nonlinear relationship between the stress and the resulting flow and turbulence levels. The objective is to merge the observed relationships with the stress-flow response functional derived from wave-kinetic models to incorporate the radial scale length and predict the long-term behavior of zonal flows including the experimentally observed turbulence bifurcations, with obvious confinement optimization implications.

P 5.5 Tu 15:25 B 302

Transport bifurcations for zonal flows in 3D sheared slab drift wave systems — •Andreas Kammel and Klaus Hallatschek — Max-Planck-Institut für Plasmaphysik, Garching b. München, Germany

The Reynolds stress-governed interaction between drift waves and zonal flows in the highly nonlinear plasma edge is examined in detail using the turbulent two-fluid code NLET. Special focus is being placed on the structure of the flows.

Already in a simple 3-dimensional sheared slab cold-ion drift wave system based on the Hasegawa-Wakatani equations, transport bifurcations containing two different stable gradients have been found - a novelty for self-consistent first principles turbulence simulations. The density profiles develop corrugations (depending on one dimensionless parameter only) which represent stationary transport states with regions of steepened gradients and lowered diffusivity for the flows opposite to the electromagnetic drift direction. These 'negative' flows, which repulse the drift wave turbulence, become sharper and steeper than the 'positive' flows, yielding a flow asymmetry which can be understood by the introduction of a chemical potential.

In the future course of our studies, we plan to compare these drift wave zonal flows in the plasma edge to the geostrophic zonal flows in the atmospheres of gas giants. To this end, a new numerical code for the hydrodynamic, planetary case will be developed.

P 5.6 Tu 15:40 B 302

Tree-Code Based Mesh-Free Simulation of a Gas-Puff — •Benjamin Berberich[1], Detlev Reiter[1], and Paul Gibbon[2] — [1]IEF-4, Forschungszentrum Jülich — [2]JSC, Forschungszentrum Jülich

Mesh free simulation techniques such as the Fast Multipole Method or so called tree algorithms have proven to be highly efficient tools in many fields of modern computational science. Among these codes the 3-dimensional, fully kinetic electrostatic Tree-Code PEPC-B has been used successfully for particle simulation in the framework of Laser-Plasma interaction. In the present work we show the principle ideas behind such methods and examples. Also results of new developments to the code are presented to make the method applicable to magnetic fusion plasma physics with emphasis on Plasma Surface Interaction topics. In particular implementation of an external B-field, as well as an additional hybrid particle-fluid collision term are discussed and verified. As a first application to a magnetic fusion problem we present results of a combined EIRENE PEPC-B simulation of a gas-puff experiment in the TEXTOR tokamak (FZ Juelich), and the resulting effects of the self-consistent E-field due to strong localized ionization. The influence of this E-field to expand the ionization cloud is investigated and compared to earlier semi-analytical predictions[1].

[1] M.Z.~Tokar; Plasma Behaviour near strong Sources of Impurities; Contrib. Plasma Phys. 36 (1996) 2/3, 250-254