P 1: Plasma Diagnostics I

Zeit: Montag 8:30–10:15 Raum: HS 2010

Hauptvortrag P 1.1 Mo 8:30 HS 2010

Using Fullwave Simulations to Understand the Turbulent Wavenumber Spectrum Measured by Doppler Reflectometry — •Carsten Lechte[1], Garrard Conway[2], Tobias Görler[2], Tim Happel[2], Carolin Tröster-Schmid[2], and The ASDEX Upgrade Team[2] — [1]IGVP, Stuttgart University, 70569 Stuttgart, Germany — [2]Max-Planck-Institut für Plasmaphysik, Boltzmannstr. 2, 85748 Garching, Germany

Doppler reflectometry is used to measure the wavenumber spectrum of the turbulent density fluctuations in fusion plasmas. Experimental Doppler spectra and density spectra from turbulence simulations show marked differences in the position and shape of the inertial range of the turbulence.

Fullwave simulations of the reflectometer show the non-linear scattering properties of the plasma at the observed density fluctuation levels and can explain these differences. In addtion, experimental Doppler reflectometry spectra from ASDEX Upgrade show a significant difference between measurements done in X and O mode polarisation, even though the underlying turbulence is the same. Turbulence simulations, together with synthetic turbulence, are used to investigate these properties of the Doppler scattering process.

P 1.2 Mo 9:00 HS 2010

Developing a Method for Measuring Plasma Radius using Schlieren Imaging — •Anna-Maria Bachmann — Max-Planck Institute for Physics, Munich, Germany

AWAKE (Advanced Wakefield Experiment) develops a new plasma wakefield accelerator using the CERN SPS proton bunch as a driver. It is propagating through a 10m long rubidium plasma, induced by an ionizing laser pulse. Since the transverse component of the wakefield has a significant value up to a radius of approximately 1mm the plasma radius must be determined experimentally, to ensure its value is larger than this value along the cell.

We use the bending of the rays of a laser pulse caused by the change of index of refraction and deflection induced by the ionizing laser pulse propagation to measure this radius. Schlieren Imaging is an optical method, which allows to increase the plasma column image contrast by blocking non-deflected rays, acting as a background, while imaging the transparent object, the plasma column in this case. The refractive index of plasma is slightly lower than 1 while the value for vapor differs strongly from 1 for light with a frequency very close to the transition frequency of the given element. Rubidium has a transition line in the visible range from the ground to the first excited state, the D2 line at 780nm. Using a tunable laser in this range, one can make the effect of the disappearing vapor in the center of the ionizing laser beam visible.

We will describe the method, explain the experimental setup and present experimental results.

P 1.3 Mo 9:15 HS 2010

Interferometer-based white light measurement of neutral rubidium density for the AWAKE experiment at CERN — •Fabian Batsch, Erdem Öz, and Patric Muggli — Max-Planck-Institut für Physik, München, Deutschland

The AWAKE experiment at CERN aims to pave the way for proton-driven plasma wakefield acceleration. One of its central parts is a unique 10 m long, temperature stabilized rubidium (Rb) vapor source. Full laser ionization of the vapor generates a 10 m long 2 mm diameter plasma channel with equal density. The optimal plasma density for wakefield acceleration is in the range of $1 \cdot 10^{14}$ to $1 \cdot 10^{15}$ cm^{-3} . Further, a density gradient along the cell (0 to 10 %) may have a positive effect on the acceleration process. The plasma density and gradient is determined by measuring optically in an automated way the vapor density at both cell ends. The diagnostic uses a coherent broadband light source, a Mach-Zehnder interferometer build out of single mode fibers and a fiber spectrograph. We apply the hook method adapted to vertical fringes. Without vapor, the interference signal intensity spectrum is sinusoidal. With vapor, anomalous dispersion occurring in the vicinity of the Rb transition lines at 780.027 nm and 794.760 nm cause a change in the distance between intensity maxima (fringes). The fringe distance becomes smaller the closer one is to the transition line and also with higher density. The Rb vapor density is obtained by fitting these curves with a function describing this change, giving a relative accuracy better 0.2 %. This diagnostic was successfully used during the first phase of the AWAKE experiment in Dec. 2016.

P 1.4 Mo 9:30 HS 2010

Kinetic Investigation of Ideal Multipole Resonance Probe — •Junbo Gong[1], Sebastian Wilczek[1], Jens Oberrath[2], Denis Eremin[1], Michael Friedrichs[2], and Ralf Peter Brinkmann[1] — [1]Institute of Theoretical Electrical Engineering, Ruhr-University Bochum, Germany — [2]Institute of Product and Process Innovation, Leuphana University Lüneburg, Germany

Active Plasma Resonance Spectroscopy (APRS) denotes a class of industry-compatible plasma diagnostic methods which utilize the natural ability of plasmas to resonate on or near the electron plasma frequency. One particular realization of APRS with a high degree of geometric and electric symmetry is Multipole Resonance Probe (MRP). The Ideal MRP (IMRP) is an even more symmetric idealization which is suited for theoretical investigations. In this work, a spectral kinetic scheme is presented to investigate the behavior of the IMRP in the low pressure regime. The scheme consists of two modules, the particles pusher and the field solver. However, due to the velocity difference, the electrons are treated as particles whereas the ions are only considered as stationary background. The particle pusher integrates the equations of motion for the studied particles. The Poisson solver determines the electric field at each particle position. The proposed method overcomes the limitation of the cold plasma model and covers kinetic effects like collisionless damping.

P 1.5 Mo 9:45 HS 2010

Evaluation of new faraday probe designs employing RF ion sources and ion thrusters — •Maximilian Quaas, Frank Scholze, Ronny Woyciechowski, Christoph Eichhorn, Carsten Bundesmann, and Daniel Spemann — Leibniz Institute of Surface Modifcation, Permoserstr. 15, 04318 Leipzig

Faraday probes are indispensable tools for measuring the beam current density of ion sources or thrusters. However, a reliable determination of the positive ion current is not a simple task, but requires to take several effects into account, for example, the emission of secondary electrons and sputtered ions as well as the contribution of electrons from the neutralizer, if applicable, that can alter the measured beam current significantly. In order to account for these sources of uncertainties, new faraday cup designs, typically comprising a screen and a repeller electrode in front of the charge-sensitive cup, were evaluated using SIMION simulations. These simulations allowed to optimize the geometrical dimensions of the components as well as the voltage applied to the repeller electrode to ensure that sputtered ions as well as secondary electrons, respectively, do not leave and neutralizer electrons do not enter the cup. The optimized faraday cups were manufactured, tested and evaluated using Xe ions from a gridded RF ion source. The measured beam profiles recorded for several distances from the source were compared with a reference cup and the calculated total currents compared to the beam current for different repeller voltages.

P 1.6 Mo 10:00 HS 2010

A simple equation for curling probe plasma diagnostics — •Ali Arshadi and Ralf Peter Brinkmann — Institute of Theoretical Electrical Engineering, Ruhr University Bochum, Germany

The recently invented plasma diagnostic device, curling probe (CP) is an innovative realization of ‘Active plasma resonance spectroscopy’. The CP is a spiral slot-type antenna. It has been used for accurate measurement of the electron density in low pressure plasmas for materials processing. Because of its planar and spiral structure, the CP is flatly embedded into the chamber wall that minimizes the perturbation. Since a thin layer of Quartz or Kapton covers the CP’s metal front, no metal impurity is released during the plasma processing. The CP excites the plasma by a weak RF signal and a network analyzer is used to monitor the power reflection coefficient. Two resonant microwave absorption are observed at specific frequencies between 2 and 5 GHz which are strongly dependent on the electron density and the spiral length. Neglecting the little spiralization effect, this work presents a mathematical model for a ‘straightened’ CP enabling us to determine the electron density for low and high pressure plasmas. A simple and very practical expression for the probe resonance is obtained considering the resonance of a half-wavelength standing wave along the probe length. Good agreement between our computations and the FDTD simulation is shown.