THE 17TH INTERNATIONAL STELLARATOR/HELIOTRON WORKSHOP

International edge turbulence data base

B. Nold[1]*, A. Dinklage[2], M. Endler[2], S. Marsen[2], M. Ramisch[1] and U. Stroth[1]

[1]*Institut für Plasmaforschung, Pfaffenwaldring 31,70569 Stuttgart, Germany*
[2]*Max-Planck-Institut für Plasmaphysik, Euratom Association 17491 Greifswald, Germany*

* nold@ipf.uni-stuttgart.de

Introduction: One of the main challenges of fusion research is a better understanding of energy and particle transport. The dominant transport losses are due to turbulence caused by micro instabilities. Plasma edge turbulence has been investigated for over 30 years in various devices and lots of similarities have been found in the turbulent behavior of tokamaks and stellarators, as well as in high and low temperature plasmas. Good progress has been achieved by combination of experimental results and comparison with simulations. The international edge turbulence data base has been initiated to concentrate these efforts. It will provide a platform for researchers to easily access and analyze data from various experiments all over the world under the aspect of inter-machine comparison and code validation. Further supply of data from additional experiments is crucial for the success of the data base. Turbulence takes place on a large number of different scales, differs locally from the plasma core to the scrape off layer (SOL) and can be investigated with a vast number of diagnostics. In a first step, the data base is limited to fluctuation data from Langmuir probes in the edge and SOL region. Probes are available on almost all plasma devices and provide localized density, potential and temperature measurements, which were found to play a key role in edge turbulence. It is possible to measure with Langmuir probes in the SOL and across the separatrix even in high density and temperature plasmas, as shown in JET, ASDEX Upgrade and W7-AS. Furthermore, Langmuir probes enable the investigation of small-scale turbulence because of their high spatial and temporal resolution. The next section addresses the objectives of this project. The structure of the data base and first results from the stellarators TJ-K and WEGA are presented in Section 3 and 4, respectively. On the other hand, a standard technique shall be developed for probe measurements, to capture fast temperature fluctuations with a well defined method at different experiments (Section 5). Finally, in Section 6 a summary is given with a call for participation in this project.

Objectives: The questions to be addressed with the data base are the experimental conditions for blob and hole generation, different regimes of blob propagation, scaling of turbulence with dimensionless parameters, extension of the available parameter range, blob transport to the wall and general description of intermittent fluctuations.

The data requested for the data base should consist of Langmuir probe measurements in the SOL and across the separatrix of magnetically confined plasmas. At least four probes should be aligned poloidally along one flux surface and radially mobile to capture profiles of the electrostatic turbulence. The probes should measure ion-saturation current

and floating potential fluctuations alternatingly to enable investigations of transport and cross-phases. Long time traces at all positions are appreciated for statistical analysis, although the measurement time is often limited by the speed of reciprocating probes.

This first contribution is intended to present the project and to involve future partners. The project consists of two topics. On the one hand, the data base is developed to collect available fluctuation data from Langmuir probes in different devices and to supply this data for systematic analysis to the community.

Data base structure: The data base is organized in three levels. The first level lists the devices, the second level lists date and shot number of the data available from a specific device. The third level contains ASCII files with meta information (device, configuration, probes, plasma) and the probe signal. There is one file per position for each signal. The continuous data from reciprocating probes has to be cut into appropriate sub windows. Appropriate sub windows are as long as possible (for statistical analysis) and as short as necessary to reduce the radial uncertainty. The meta information contains the mean distance of the probes to the separatrix d_s after mapping to the magnetic mid-plane to allow fast and easy data evaluation. On the other hand, the sub windows can be joined to obtain the continuous time trace in absolute time for comparison with global discharge parameters. The meta information contains further the absolute probe positions in the torus, to address 2D and plasma shaping effects. Routines to save and access probe data in the edge turbulence data base are available in the programming language 'IDL' and will soon also be available in 'MatLab'. Further, it will be possible to save additional information as background profiles or the shape of the separatrix. First data from the torsatron TJ-K and the stellarator WEGA are saved in the data base.

First results: In a first attempt, members of the TJ-K and WEGA Team analyzed data from both machines independently. This proved the usability of the data base and revealed promising similarities in the turbulent fluctuations of TJ-K and WEGA, as shown in Fig. 1. The relative fluctuation level is increasing from 20% in the confined plasma to over 60% in the SOL. The skewness profiles indicate 'holes' in the confined plasma and 'blobs' in the SOL of both devices. Both kinds of events are supposed to be generated by an interchange mechanism around the zero transition of the skewness profiles. The peakedness of the probability density function reaches a minimum at this same position, which is located inside and outside the separatrix for TJ-K and WEGA, respectively. The radial shift between the profiles of both devices was also seen in the cross-field particle flux and might be caused by poloidal asymmetries. A better understanding of these differences and the comparison with other devices is subject of further investigations.

Standard for probe measurements: Presently, for an estimate of radial transport from Langmuir probe measurements, mostly I_{sat} and Φ_{float} are measured with poloidally displaced probe tips, while T_e fluctuations are neglected. However, on several devices, swept Langmuir probes measured the probe characteristics with frequencies over 1 MHz, which were large compared with typical fluctuation frequencies, such that n, T_e and Φ_{pl} fluctuations could be calculated for each probe tip ([1] and references therein). Interest-

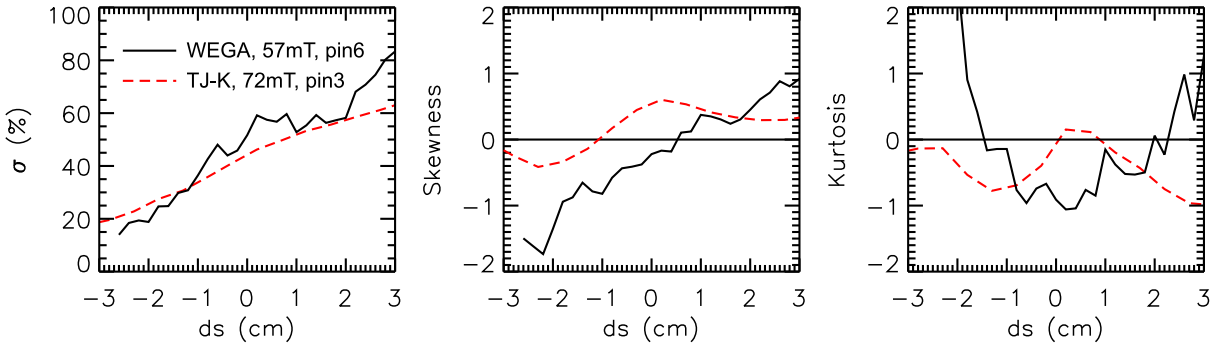

Fig. 1: Statistical moments of ion-saturation current fluctuations around the separatrix in TJ-K and WEGA.

ingly, the relative phases between these three fluctuating plasma quantities were observed to vary radially, although the relative phase between I_{sat} and Φ_{float} fluctuations did not alter much (Fig. 2).

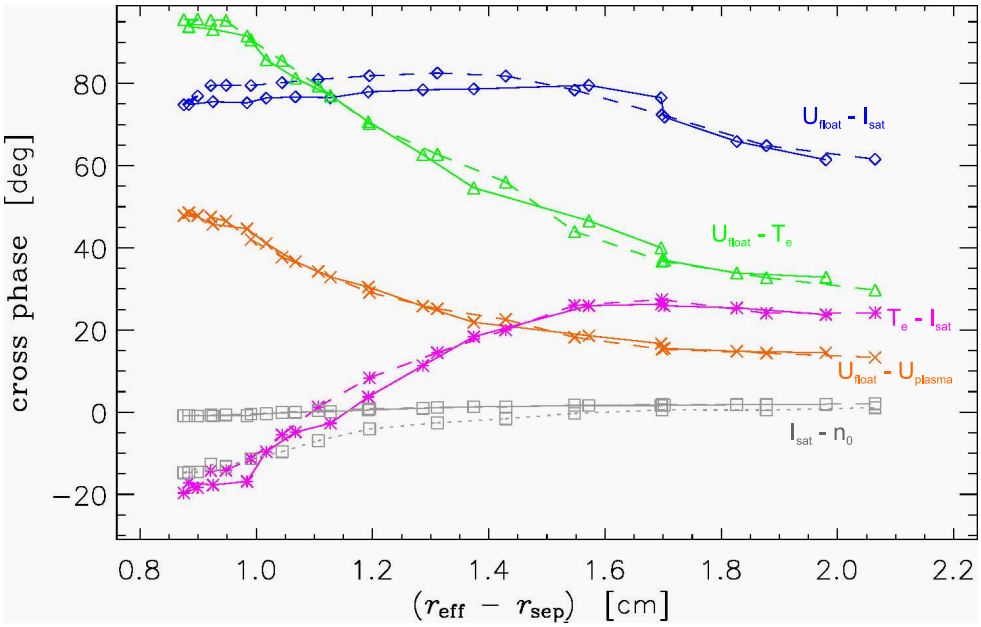

Fig. 2: Profiles of the power weighted cross phase between primary fit parameters and plasma quantities as a function of the radial position in W7-AS. Solid lines correspond to the inward and dashed lines to the outward movement of the probe. Figure reproduced from [1, Fig. 5.25].

We therefore conclude, that for the fluctuation data in the data base to be relevant for transport, a probe technique delivering n, T_e and Φ_{pl} fluctuations, like the fast sweeping technique, should be made the standard.

To achieve this goal, a few open questions still need to be investigated:

- A comparison between I_{sat} and Φ_{float} measurements from fast swept and from stationary probe tips in the same discharge should be performed on several devices. The same would be useful for Φ_{pl} fluctuations from fast swept and from emissive

probes, and possibly a comparison with further advanced electric probe techniques should be done.

- In case of too high frequency components in the fluctuating quantities, covariances between the fit parameters in fast swept probe measurements will pretend false cross correlations or phases between the plasma parameters. The analysis procedure should be investigated and extended to identify the uncertainties arising through to the final results of the data analysis (like phases, transport, etc.).

- The impact of T_i (average value as well as fluctuation amplitude) on the probe model underlying the analysis of fast sweeping must be investigated in more detail, and measurements yielding some information on T_i at the location of the probe tips should be envisaged.

Fast sweeping Langmuir probes impose additional experimental difficulties. The fast sweeping technique shall be further developed in the low temperature plasma of the WEGA stellarator to obtain a robust system for temperature fluctuation measurements in various plasma conditions.

Conclusions and invitation: The project of the international edge turbulence data base has been launched. A data base was set up and first data sets of electro static fluctuations have been successfully included. Combined analysis of the statistical properties and cross-phases showed good agreement between the devices and proved the usability of the data base. In the next step, Langmuir probe data is requested from tokamaks and stellarators with different configurations and plasma conditions to enable extensive comparisons of turbulent properties in the edge/SOL region of magnetically confined plasmas. In parallel, the problem of temperature fluctuations is addressed by further development of the fast sweeping Langmuir probes. We want to encourage the scientific community to supply data from their experiments to the data base and to work with the joint data. Please contact the authors for further information and contribution.

References

[1] M. Schubert, PhD Thesis, Greifswald (2005), http://edoc.mpg.de/get.epl?fid=17419&did=246340&ver=0