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Experimental Turbulence Studies for Gyro-Kinetic Code Validation Using Advanced Microwave Diagnostics

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Turbulent transport remains one of the most important and challenging topics in fusion research. Scientific understanding of the related physical processes can only be enhanced through a close comparison of numerical simulations with experimental data. Microwave-based diagnostics represent almost the sole experimental approach capable of capturing plasma parameter fluctuations with the required spatio-temporal resolution. This contribution reports on an extensive international effort undertaken on the devices ASDEX Upgrade, TCV, Tore-Supra and W7-X to measure simultaneously a large spectrum of fluctuation parameters to achieve a comprehensive comparison with theoretical models and advanced numerical turbulence simulations. An overview is given of the work, which is coordinated by the Virtual Institute on Plasma Dynamical Processes and Turbulence Studies using Advanced Microwave Diagnostics including first results and advanced hard-ware developments relevant for reflectometry on future devices such as ITER and DEMO.

In the present campaign a full suite of new reflectometers is available on ASDEX Upgrade. The paper summarises the results achieved: Scale-resolved radial turbulence levels in H-mode discharges were measured and compared to GENE simulations in the transition range from ion-temperature-gradient to trapped-electron-mode turbulence. A correlation Doppler reflectometer is used for measuring the GAM structure in discharges where poloidal flow damping was varied by means of variations of the shape of the poloidal plasma cross-section and the isotope mass; results are compared with NEMORB simulations. A 2D correlation reflectometer is used to investigate the spatial structure of turbulent fluctuations and to address questions related to turbulence anisotropy and systematic eddy tilting in the flow-shear layers at the plasma edge. The aspects of turbulence spreading and non-local transport in response of local changes in density and temperature gradients are studied during phases with L-H transitions and power modulation by means of radial correlation measurements and an ultra-fast reflectometer, capable of scanning a large radial sector of the plasma within less than 2 µs. Furthermore, reflectometry solutions using advanced hard-ware components without moving parts will be presented, for monitoring plasmas in the harsh environment of fusion reactors.

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