Experimental Investigation of Turbulence in the Wendelstein 7-X Stellarator with Phase Contrast Imaging

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In the recent experimental campaign OP 1.2a of Wendelstein 7-X (W7-X), currently the world's largest optimized stellarator with a plasma volume of $30\,\mathrm{m}^3$, high-performance discharges with a maximum stored energy of 1MJ were achieved. As one of the optimization criteria of W7-X was the reduction of neoclassical transport, turbulent transport mechanisms are believed to play a much more important role now. Numerical gyrokinetic simulations suggest a significantly different appearance of turbulence in stellarators than in tokamaks. However, a systematic experimental investigation of turbulence in optimized stellarators has not been done, yet. To address this topic the phase contrast imaging (PCI) diagnostic was installed at W7-X and successfully put into operation in the recent experimental campaign OP 1.2a. The PCI diagnostic allows for non-invasive spatiotemporal measurements of electron density fluctuations. It is sensitive to ion temperature gradient turbulence and trapped electron modes – in the hot core up to the colder edge.

Gyrokinetic simulations have shown that density fluctuations depend strongly on geometrical effects. One particular aspect is the influence of the elongation or the correlated inverse safety factor iota on the development of ion temperature driven turbulence [1]. In W7-X different magnetic field configurations were used which allow for an experimental comparison. Since W7-X uses as main heating source electron cyclotron resonance heating, the ion-temperature is influenced by the coupling between ions and electrons which depends on the plasma density. With this in mind ion temperature gradient driven turbulence is expected to be dependent on the experimentally accessible plasma density. In order to gain insights in the underlying mechanisms, the experimental analysis is accompanied by comparisons to data obtained from GENE. This gyrokinetic code allows for investigating numerically ion temperature gradient driven instabilities based on actual experimental configurations and profiles.

References

[1] P. Xanthopoulos et al., Phys. Rev. Lett. 113, 155001 (2014)