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Flow and phase velocity of turbulence in magnetized fusion plasmas

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Turbulence and flows play a key role in tokamak plasmas performance.
The aim of the present contribution is to gain insight into the nature of the instability at the origin of the turbulence and its impact on the flow by studying the dynamics of the density fluctuations and by identifying the contribution coming from the "phase velocity"of the density fluctuations. Doppler backscattering (DBS) gives access to the intensity and velocity of density fluctuations at a selected spatial scale. The velocity detected is the sum of the mean flow plasma velocity plus the phase velocity of the density fluctuations. In the most common case, density fluctuations are considered as tracers that are advected by the plasma that give access to the velocity of the plasma flow. In this sense, the intrinsic velocity of the fluctuations, which corresponds to the phase velocity in a linear stability analysis, is considered negligible. This approximation seems appropriate at the edge of the plasma where the mean flow velocity can be large. However, depending on the plasma conditions, this phase velocity can contribute significantly to the measured velocity. An evaluation of its amplitude can be obtained by measuring the evolution of the density fluctuations velocity as a function of the wavenumber, since the mean flow velocity does not depend on the wavenumber. New experiments have been carried out in the WEST tokamak to evaluate the wavenumber dependence of the density fluctuations velocity by changing the probing angle during the stationary phase of a single discharge.
Furthermore, in order to go beyond this amplitude assessment, combined studies using full-wave simulations and results from first-principles numerical simulations in different plasma conditions (close or far above the instability threshold) are performed to characterise the density fluctuation velocity as a function of the wavenumber.

Author: Dr VERMARE, Laure (LPP)

Presenter: Dr VERMARE, Laure (LPP)

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