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A comprehensive study of electrostatic turbulence and transport in the laboratory basic plasma device TORPEX

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TORPEX is a toroidal device located at the CRPP-EPFL in Lausanne. In TORPEX, a vertical magnetic field superposed on a toroidal field creates helicoidal field lines with both ends terminating on the torus vessel. The turbulence driven by magnetic curvature and plasma gradients causes plasma transport in the radial direction while at the same time plasma is progressively lost along the field lines. The relatively simple magnetic geometry and diagnostic access of the TORPEX configuration facilitate the experimental study of low frequency instabilities and related turbulent transport, and make an accurate comparison between simulations and experiments possible.
We first present a detailed investigation of electrostatic interchange turbulence, associated structures and their effect on plasma using high-resolution diagnostics of plasma parameters and wave fields throughout the whole device cross-section, fluid models and numerical simulations. Interchange modes nonlinearly develop blobs, radially propagating filaments of enhanced plasma pressure. Blob velocities and sizes are obtained from probe measurements using pattern recognition and are described by an analytical expression that includes ion polarization currents, parallel sheath currents and ion-neutral collisions.
Then, we describe recent advances of a non-perturbative Li 6+ miniaturized ion source and a detector for the investigation of the interaction between supra thermal ions and interchange–driven turbulence. We present first measurements of the spatial and energy space distribution of the fast ion beam in different plasma scenarios, in which the plasma turbulence is fully characterized. The experiments are interpreted using two-dimensional fluid simulations describing the low-frequency interchange turbulence, taking into account the plasma source and plasma losses at the torus vessel. By treating fast ions as test particles, we integrate their equations of motion in the simulated electromagnetic fields, and we compare their time-averaged and statistical properties with experimental data. Finally, we discuss future developments including the possibility of closing the magnetic field lines and of performing magnetic reconnection experiments.