Overview of ASDEX Upgrade results - DTU Orbit (09/11/2017)

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The medium size divertor tokamak ASDEX Upgrade (major and minor radii 1.65 m and 0.5 m, respectively, magnetic-field strength 2.5 T) possesses flexible shaping and versatile heating and current drive systems. Recently the technical capabilities were extended by increasing the electron cyclotron resonance heating (ECRH) power, by installing 2 × 8 internal magnetic perturbation coils, and by improving the ion cyclotron range of frequency compatibility with the tungsten wall. With the perturbation coils, reliable suppression of large type-I edge localized modes (ELMs) could be demonstrated in a wide operational window, which opens up above a critical plasma pedestal density. The pellet fuelling efficiency was observed to increase which gives access to H-mode discharges with peaked density profiles at line densities clearly exceeding the empirical Greenwald limit. Owing to the increased ECRH power of 4 MW, H-mode discharges could be studied in regimes with dominant electron heating and low plasma rotation velocities, i.e. under conditions particularly relevant for ITER. The ion-pressure gradient and the neoclassical radial electric field emerge as key parameters for the transition. Using the total simultaneously available heating power of 23 MW, high performance discharges have been carried out where feed-back controlled radiative cooling in the core and the divertor allowed the divertor peak power loads to be maintained below 5 MW m−2. Under attached divertor conditions, a multi-device scaling expression for the power-decay length was obtained which is independent of major radius and decreases with magnetic field resulting in a decay length of 1 mm for ITER. At higher densities and under partially detached conditions, however, a broadening of the decay length is observed. In discharges with density ramps up to the density limit, the divertor plasma shows a complex behaviour with a localized high-density region in the inner divertor before the outer divertor detaches. Turbulent transport is studied in the core and the scrape-off layer (SOL). Discharges over a wide parameter range exhibit a close link between core momentum and density transport. Consistent with gyro-kinetic calculations, the density gradient at half plasma radius determines the momentum transport through residual stress and thus the central toroidal rotation. In the SOL a close comparison of probe data with a gyro-fluid code showed excellent agreement and points to the dominance of drift waves. Intermittent structures from ELMs and from turbulence are shown to have high ion temperatures even at large distances outside the separatrix.

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