Parameter dependences of the separatrix density in nitrogen seeded ASDEX Upgrade H-mode discharges

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A very important interface parameter between core plasma performance and divertor power exhaust is the electron density at the separatrix. In a simple picture, a low separatrix density is beneficial for the plasma energy confinement, while a high density supports the achievement of divertor detachment. Direct measurements of the (upstream) separatrix density are not easily available. The major experimental problem stems from the assignment of the separatrix position from equilibrium reconstruction, which suffers uncertainties which are comparable to the radial density decay length. To overcome this problem, Thomson scattering (TS) is used which measures $T_e$ and $n_e$ at the same location. The separatrix position can be assigned via the power flux $P_{sep} = P_{heat} - P_{rad}$ and an estimate for the width of the power carrying layer, $\lambda_q \approx 2/7\lambda_{Te}$.

The lack of a large experimental data base of the separatrix density is the reason for a lack of scalings of this quantity with engineering parameters like machine radius $R$ or plasma current $I_p$. Often, a constant fraction of separatrix density and Greenwald density, $n_{e,sep}/n_{GW}$ is assumed. Due to the large $I_p$ ratio between current experiments and, e.g., ITER, the parameter dependence of $n_{e,sep}$ on $I_p$ is of particular importance. Regarding power exhaust, in addition to the separatrix density, the power width $\lambda_q$ and its divertor broadening $S$ are important. $\lambda_q$ was found to scale $\propto 1/B_p$, thus $1/I_p$ at $R=const.$ [1].

In this paper, an experimental data base is presented of nitrogen seeded AUG H-mode discharges with sufficiently constant seeding level and $n_e$, $T_e$ measurements by the edge TS system [2]. The upstream separatrix density is found to correlate mainly with the divertor neutral pressure, $n_{e,sep} \propto p_0^{0.3}$. A trend of rising $n_{e,sep}$ with increasing plasma current is related to operational conditions, like the necessity of a higher gas puff at higher currents for tungsten accumulation avoidance. The measurements are also interpreted by means of simple 1D modelling of the outer SOL [3].

References