L-H Transition Physics Investigated at ASDEX Upgrade

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When investigating the power threshold of the L-H transition in ASDEX Upgrade, a correlation between the L-H transition and the edge pressure gradients of the ions has been observed. Detailed evaluations demonstrate that for all electron densities the L-H transition takes place, when at the plasma edge $\nabla p_i/(en_i)$ approaches a minimum value of about -15kV/m at a magnetic field of 2.5T [1]. This threshold in $\nabla p_i/(en_i)$ is independent of the collisional electron-ion coupling and the applied heating scheme (electron or ion heating). According to the radial force balance for the main ions, $\nabla p_i/(en_i)$ corresponds to the radial electric field (E_r) for negligible poloidal and small toroidal rotation of the main ions and small effects of turbulence [2]. This picture naturally gives rise to a sheared E_rxB flow due to the strong spatial variation of $\nabla p_i/(en_i)$, which then is thought to cause the establishment of the transport barrier, if the shear flow exceeds a critical shear. Note that the absolute value of E_r does not imply a shear flow, however, the structure of $\nabla p_i/(en_i)$ has the appearance of a well with a virtually constant width, such that the minimum electric field of the E_r well is characteristic for the shear in E_r and its associated flows. Consistently to that interpretation, it is observed at ASDEX Upgrade that the transport barrier collapses, i.e. the H-L transition occurs at the exact same values for the minimum of $\nabla p_i/(en_i)$ at which the L-H transition takes place [3]. In order to directly test these observations a fast E_r measurement based on CXRS has been implemented for simultaneously measuring the kinetic profiles of ions and E_r on time scales of about 50-100 μs. Along the same lines, the influence of intermittent zonal flows, i.e. the so-called I-phase, as diagnosed by Doppler reflectometry [4] is presented, as it seems possible that these zonal flows yield the trigger for the L-H transition.

Investigations at ASDEX Upgrade revealed a decrease of the L-H power threshold by about 25% for the plasmas after the transition from a full carbon wall to a full tungsten wall [5], in accordance to the observations at JET-ILW. Simultaneously, to this change in power threshold also changes in the edge profiles are observed and a correlation to the edge E_r seems probable.

An investigation of density transport at the edge was enabled by the high data quality of the electron density measurements from the Li-beam at ASDEX Upgrade and its implementation into the integrated data analysis framework combining edge measurements with those from the interferometers. The density rise after the formation of an edge transport barrier was investigated and modelled with ASTRA in order to determine the diffusion coefficient and convection velocity for particle transport [6]. A good match between model and measurements could be obtained by considering only a strongly reduced diffusive transport. However, a slightly improved fit was obtained by adding a pinch in the range of 1m/s to the diffusive edge transport barrier.

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