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MHD limits and plasma response in high beta hybrid operations in ASDEX Upgrade

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The improved H-mode scenario (or high β hybrid operations) is one of the main candidates for high-fusion performance tokamak operation, which could potentially reach the steady-state condition. In this case, the normalized pressure β_N must be maximized and pressure driven instabilities limit the plasma performance. These instabilities could have either resistive ((m=2,n=1) and (3,2) Neoclassical Tearing Modes (NTMs)), or ideal character (n=1 ideal kink modes). In ASDEX Upgrade (AUG), the first limit for maximum achievable β_N is set by NTMs. Application of pre-emptive electron cyclotron current drive at the q=2 and q=1.5 resonant surfaces reduces this problem, such that higher values of β_N can be reached. AUG experiments have shown that, in spite of the fact that hybrids are mainly limited by NTMs, proximity to the no-wall limit leads to amplification of external fields that strongly influences the plasma profiles: for example, rotation braking is observed throughout the plasma and peaks in the core. In this situation, even small external fields are amplified and their effect becomes visible. To quantify these effects, the plasma response to magnetic fields produced by B-coils is measured as β_N approaches the no-wall limit. These experiments and corresponding modelling allow to identify the main limiting factors which depend on the stabilizing influence of conducting components facing the plasma surface, existence of external actuators and kinetic interaction between the plasma and the marginally stable ideal modes. Analysis of the plasma reaction to external perturbations allowed us to identify optimal correction currents for compensating the intrinsic error field in the device. Such correction, together with analysis of kinetic effects, will help to increase β_N further in future experiments.

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