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Spectroscopic Characterization of Conventional versus Alternative Divertor Configurations

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Addressing climate change requires sustainable, carbon-free energy sources.
A promising solution could be the use of fusion power, where electricity is generated from the heat released during nuclear fusion reactions.
For them to occur, the fuel, i.e. the hydrogen isotopes deuterium and tritium, must be in a state of plasma and exhibit sufficient temperature, density, and confinement time.
In magnetic confinement fusion devices, such as ASDEX Upgrade (AUG) in Garching, Germany, the plasma is confined by strong magnetic fields.
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Particles and heat escaping the confined region are diverted by a magnetic configuration, the so-called divertor, onto dedicated plasma-facing components.
While current devices operate within material limits, projections for next-step facilities indicate that heat fluxes to the divertor targets may exceed tolerable thresholds.
Therefore, operation in a detached regime is envisaged, where the electron temperature near the target is reduced (e.g. via impurity seeding), enabling volumetric energy and momentum losses primarily through radiation, charge exchange, and recombination before reaching the target plates.
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At AUG, two magnetic field coils were recently installed in the upper divertor with the aim of investigating alternative divertor configurations (ADCs) as a means of mitigating power exhaust\,\footnote{I. Zammuto et al. \textit{Fusion Eng. Des.} 2021. DOI: 10.1016/j.fusengdes.2021.112468}. To study the plasma parameters in the upper divertor volume, we present a spectroscopic technique that infers local electron densities from Stark broadening of high-n Balmer lines and electron temperatures from Saha equilibrium considerations. Furthermore, the diagnostic allows the measurement of the seeding impurity ion density.
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In this contribution, we present electron temperature profiles measured in both conventional and alternative divertor configurations. For each configuration, we determine the impurity seeding rates required to reach detachment, and we show that the detachment onset is achieved at lower seeding rates in the ADCs.

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