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Power exhaust by core radiation at the COMPASS tokamak

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Plasma detachment is the desired operational regime for ITER baseline scenario and in next-step fusion reactors, as it allows to reduce the heat fluxes impacting onto the divertor plasma-facing components (PFCs) below their material limits. It is typically characterized by a reduction of plasma pressure between the upstream separatrix and the divertor targets, which is caused by dissipation of power in the scrape-off layer (SOL) and divertor region. One of the ways to achieve detachment is seeding of impurities, which continuously radiate power and consequently cool the surrounding plasma.

In contemporary machines, the primary aim is to concentrate such radiation in the divertor region or SOL and minimize the impact of impurities on the confined plasma. For such purpose, lighter impurities, such as nitrogen or carbon, appear to be the best choice. However, in ITER and future machines (such as the European DEMO concept), the reduction of power required for safe operation of the divertor PFCs is so dramatic (80% and 98% respectively), that it could hardly by achieved only by radiation outside the separatrix. Indeed, some power will have to be radiated already in the confined region, preferably in the narrow mantle located outside the top of the pedestal. In order to do so, heavier impurities (such as the noble gases), should be employed.

In this work we report on experiments at COMPASS tokamak, where neon and argon were injected in ohmic or NBI-heated low confinement plasmas. With appropriate seeding waveform, stable scenarios were achieved, avoiding the radiative collapse of plasmas. Significant reduction of heat fluxes at the outer target was observed, with heat flux pattern similar to the one previously achieved by nitrogen seeding [1]. The reduction of downstream pressure was, however, caused by an equal reduction of upstream pressure, indicating that the power dissipation occurred inside the separatrix. Indeed, the impurity cooling is causing a significant drop of edge temperature, however the effect in the plasma center is much less pronounced.

References

[1] M. Komm et al., Nucl. Fusion 59 (2019) 106035

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