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Enrichment of impurities seeded for exhaust control in spherical tokamak power plant geometry

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Concentrated exhaust power deposition must be avoided in a fusion power plant. A strategy to prevent this is to seed heavy impurities in the divertor, which radiate strongly at the local plasma temperature. This can help to maintain a uniform power deposition over the divertor structure. However, if the impurity migrates upstream, it can produce a number of detrimental effects, including fuel dilution and strong radiative power loss. Measures of the success with which the impurity is localised to the divertor are the impurity enrichment, which is the ratio of the impurity concentration in the divertor to that upstream, and the impurity compression, which is the ratio of the impurity density in the divertor to that upstream.

Using SOLPS-ITER simulations, we have investigated the localisation of seeded argon in a power plant-class connected double null diverted spherical tokamak geometry, with a well-baffled, extended outer divertor leg and fairly open, short, inner divertor leg. We find that the mean free path of the neutral argon is short compared to the size of the divertor legs for the range of plasma scenarios explored. The argon enrichment and compression can thus be increased past the detachment point of the outer leg, and the enrichment and compression of the inner divertor leg can be achieved with direct impurity seeding. By comparison, we find that neon, with a higher first ionization potential, has a longer mean free path [1,2] and weaker enrichment and compression, does not cool the plasma as effectively, and thus is less suitable for use at this scale.

[1] S. S. Henderson, *et al.*, *Nucl. Fusion* **63** 086024 (2023)

[2] I. Yu Senichenkov, *et al.*, *Plasma Phys. Control. Fusion* **61** 045013 (2019)

Primary author: NEWTON, Sarah (UKAEA)

Co-authors: Dr MOULTON, David (UKAEA); Dr MYATRA, Omkar (UKAEA); Dr OSAWA, Ryoko (UKAEA); Dr HENDERSON, Stuart (UKAEA); Mr BADICEL, Vlad (UKAEA)

Presenter: NEWTON, Sarah (UKAEA)

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