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Particle and energy transport in turbulence reduced NBI scenarios at W7-X

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In the 2018 Wendelstein 7-X experiment campaign, discharges above a threshold initial density and heated only with neutral beam injection (NBI) exhibited strong central density peaking. The steep density gradients lead to an effective heat diffusivity of $\chi \sim 0.25$ m^2s^{-1}, significantly lower than the typical diffisivity of $\chi \sim 1$ m^2s^{-1} observed in most ECRH heated and gas-fuelled plasmas.

During the last experimental campaign in 2023, the scenario was explored by introducing a variable amount of additional O2-mode electron cyclotron resonance heating (ECRH) to NBI plasmas with developed peaked density profiles. In this contribution it is shown that with a specific balance of NBI and ECRH, the reduced heat transport can be exploited to produce plasmas with higher core temperatures and longer confinement times than typical ECRH plasmas and that this can be maintained for over several confinment times. The strong central peaking during the NBI-only phase is due to the presence of an anomalous pinch together with an abrupt reduction in the anomalous particle diffusion. The introduction of too much ECRH power leads to a collapse of the steep density gradient and loss of the improved confinement. A detailed analysis of the heat and particle transport in the these discharges are given, including the effect of different magnetic configurations and predictions for future experiments with additional NBI power. The results are presented in relation to the impurity transport, which reduces to neoclassical levels in the NBI-only heated phase and in relation to the heat transport in the other classes of plasma with strong density gradients.