Turbulence studies in NBI heated discharges by the Phase Contrast Imaging diagnostic in the Wendelstein 7-X stellarator

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The Wendelstein 7-X (W7-X) stellarator is optimized for reduced neoclassical transport, leaving the turbulence-driven anomalous transport as the major loss channel of particles and energy. A phase contrast imaging (PCI) diagnostic [1] has been implemented and operated to measure line-integrated, ion-scale density fluctuations with the aim of studying plasma turbulence. In the recent operational campaign [2], a limit of core ion temperature has been observed under a wide range of density and electron temperatures, which is significantly lower than the expected value based on neoclassical transport estimates [3]. Improved confinement has been achieved in high performance discharges with steep density gradients through a series of cryogenic pellet injections, where turbulence reduction was observed by PCI [4]. In contrast, discharges with direct ion heating by neutral beam injection (NBI) show no significant rise of the ion temperature, despite a centrally peaked density profile being developed during the discharge [5]. The PCI measurements show that the absolute density fluctuation amplitude remains nearly unchanged, while the plasma density and its gradient gradually increase due to the fueling from NBI. Introducing additional ECH heating leads to a transient increase of the ion temperature, followed by a flattening of the central density profile and increased turbulence, after which the ion temperature falls back to its limit.

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