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Phase contrast imaging measurements and numerical simulations of turbulent density fluctuations in gas-fuelled ECRH discharges in Wendelstein 7-X

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The fundamental nature of turbulent density fluctuations in standard Wendelstein 7-X (W7-X) stellarator discharges is investigated experimentally via phase contrast imaging (PCI) in combination with gyrokinetic simulations with the code GENE. We find that density fluctuations are ion-temperature-gradient-driven and radially localised in the outer half of the plasma. It is shown that the line-integrated PCI measurements cover the right range of wavenumbers and a favourable toroidal and poloidal location to capture some of the strongest density fluctuations in W7-X. Due to the radial localisation of fluctuations, measured wavenumber–frequency spectra exhibit a dominant phase velocity, which can be related to the $\boldsymbol{E} \times \boldsymbol{B}$ rotation velocity at the radial position of a well in the neoclassical radial electric field. The match is robust against variations of heating power and line-integrated density, which is partly due to the localisation of fluctuations and partly due to effects of the radial gradient in the $\boldsymbol{E} \times \boldsymbol{B}$ velocity profile on the wavenumber–frequency spectrum. The latter effect is studied with a newly built synthetic PCI diagnostic and global gyrokinetic simulations with GENE-3D.

Key words: fusion plasma

1. Introduction

The Wendelstein 7-X (W7-X) stellarator is optimised for reduced neoclassical transport (Beidler *et al.* 1990). Results from the first operation phase with an island divertor strongly

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