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The Wendelstein 7-X phase contrast imaging diagnostic

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ABSTRACT: A phase contrast imaging (PCI) diagnostic has been developed for the Wendelstein 7-X (W7-X) stellarator. The PCI diagnostic provides a line-integrated measurement of turbulent electron density ïňĆuctuations, which is essential for understanding high performance scenarios that can lead to improved confinement at fusion-relevant temperatures and densities. The PCI system is also sensitive to coherent ïňĆuctuations, which arise from Alfvén eigenmodes or other MHD activity. This paper provides an overview of the hardware and the optical system and presents an example PCI measurement from the W7-X OP1.2b experimental campaign.

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Contents

1 Introduction

Wendelstein 7-X (W7-X) is the largest optimized stellarator in the world, designed to create a reactor-relevant plasma under steady-state conditions. One of the major optimization criteria is the reduction of the neoclassical transport compared to classical stellarators [1]. First strong evidence of this has been obtained in the second operation campaign which introduced a carbon divertor, wall passivation by boronization and neutral beam injection (NBI) heating [2] in addition to the existing electron cyclotron heating (ECRH). The observed plasma confinement of heat and particles is indeed to a large extent dominated by turbulent transport [3]. Similar to the situation observed in tokamaks, turbulent transport is altered in W7-X when the central plasma density is peaked, which has been achieved by central plasma fueling either by hydrogen pellet injection or NBI fueling [4]. In these kind of discharges, a record triple product for stellarators was achieved [5].

Theoretical and gyrokinetic simulation studies suggest that ion-scale turbulence, in particular, ion temperature gradient (ITG) and trapped electron modes (TEM), are the primary transport relevant instabilities in the W7-X core plasma [6, 7], whereas transport by electron-scale instabilities is generally strongly reduced [8]. Validating these predictions against experimental measurements is important to understand the role of turbulence and to achieve high performance scenarios in W7-X and upcoming next generation devices like ITER. Various fluctuation diagnostics from the