Initial Measurements of Turbulence on W7-X with Phase Contrast Imaging

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Phase contrast imaging (PCI) is an internal reference beam interferometric technique which provides a direct image of line integrated electron density fluctuations in a plasma. The method has been used with great success to measure waves and turbulence in magnetically confined fusion plasmas [1]. The technique allows one to detect the variation of the index of refraction of a dielectric medium (such as a plasma) due to the presence of waves or turbulent density fluctuations. The concept relies on the introduction of a phase plate in the light beam path, causing a 90° phase shift in the unscattered portion of the beam relative to the scattered one. The two expanded beams are subsequently combined and imaged onto a cryogenically cooled detector array, thus allowing one to measure wavelengths and correlation lengths of fluctuations. A variety of unstable modes have been measured on tokamaks with PCI, including ITG and TEM turbulence, quasi-coherent modes form the plasma edge, Alfvén wave cascades and mode converted ICRF waves [1]. For practical reasons, typical wave numbers that can be measured with PCI using a CO_2 laser at 10.6 μm wavelength are in the range of $1.5 \leq k(cm^{-1}) \leq 30$ and frequencies of 10 kHz to 2.0 MHz. Nevertheless, we note the recent extension of the PCI diagnostic capability on the DIII-D tokamak where it was combined with an interferometer method to measure long wavelength fluctuations ($0 \leq k(cm^{-1}) \leq 4.0$) at frequencies up to 1 MHz, and core MHD modes not otherwise visible with magnetic loop probes were detected [2]. In the past two years, a PCI diagnostic has been implemented in the Wendelstein 7-X stellarator at IPP Greifswald, and has been commissioned during last summer's campaign, OP1.2a. The PCI operation will be continued in the OP1.2b campaign this summer. Initial results will be presented, showing the presence of broadband turbulence as well as Alfvén wave phenomena in ECH heated plasmas. The physical mechanism Alfvén mode excitation in exclusively ECH heated plasmas is under investigation. Possible driving mechanisms include gradients of the thermal electron pressure or trapped electrons [3].

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References.

[1] M. Porkolab, Proceedings of IEEE Transactions on Plasma Science, **34**, 229 (2006)
[2] E. Davis, invited talk, HTPD2018, San Diego, Ca, submitted to Rev. Sci. Instr. for publication
[3] M. Valovic, B. Lloyd, K.G. McClements et al, Nuclear Fusion **40,** 1569 (2000)