Tangential viewing phase contrast imaging for turbulence measurements

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Phase contrast imaging (PCI) is an established and powerful technique for measuring density fluctuations in plasmas [1] and has been successfully applied to several fusion devices [2-4]. Rooted in a concept first developed for microscopy [5], PCI belongs to the category of internal-reference interferometers and has been shown to possess superior qualities among such techniques, particularly in terms of spatial linearity. In essence, it produces a true image of fluctuations in the plane perpendicular to the propagation direction of the probing laser beam, provided their characteristic spatial scale is smaller than the beam width. The measurement in itself is line-integrated and thus not spatially resolved longitudinally to the beam. However, the properties of the turbulence itself can be exploited to achieve longitudinal resolution, particularly when the beam propagates nearly tangentially to the magnetic field. As micro-fluctuations are known to propagate perpendicularly to the magnetic field (**B**), and line integration naturally selects wave vectors perpendicular to the direction of beam propagation ($\mathbf{k_0}$), only wave vectors aligned along the local $\mathbf{B}\mathrm{x}\mathbf{k_0}$ direction contribute to the signal. Selecting the measured wave vector through spatial filtering thus localizes the measurement to a segment along the beam path.

This intiuitive picture has been recently rigorously tested through numerical modeling, which has revealed significant additional complexity while confirming the general principle [6].

Tangential PCI has been employed extensively in the TCV tokamak and has resulted in a rich body of work on broadband microturbulence in the TEM/ITG range [7], on geodesic acoustic modes (GAMs) [8], and on macroscopic MHD modes; this work will be reviewed in this contribution. A similar diagnostic arrangement is also at an advanced planning stage for the new superconducting tokamak JT-60SA [9] and will be presented here.

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