Design of an ultrahigh-bandwidth Phase Contrast Imaging system for fusion grade devices

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A preliminary design of a novel Phase Contrast Imaging (PCI) system that uses probing light in the Near-Infrared region is presented with application to fusion grade devices. The PCI diagnostic is an internal reference interferometer that creates an image of electron density fluctuations integrated along the line of sight of the probing laser beam. Conventional PCI diagnostics installed on worldwide fusion experiments employ laser light of wavelength equal to 10.6 um. A prototype PCI system using light at 1.55 um wavelength was developed on a bench-top to extend the spectral response in wave-number and frequency by factors of seven and over one hundred, respectively [1]. When absolutely calibrated using piezoelectric transducers and imaged onto properly sized arrays of detectors, such a system can potentially provide quantitative measurements of the internal structure of density perturbations induced by either turbulent or radio-frequency waves, simultaneously covering ion to electron gyro-radius scales up to the GHz frequency region. Being an internal reference interferometer, the PCI signal is insensitive to mechanical vibrations as long as proper alignment is maintained. The performance requirements for active feed-back systems stabilizing the position of a 1.55 um laser beam are evaluated and compared to those of conventional systems. Exploratory designs for such a diagnostic in fusion grade devices are presented, covering a variety of options in terms of system complexity, beam path lengths, spectral response, expected signal to noise ratio and corresponding overall costs for a given performance.

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