Instrumentation Development for a Novel Local Electric Field Fluctuation Diagnostic[1]

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A new diagnostic measuring local E(r,t) fluctuations is being developed for fundamental studies of plasma turbulence in tokamaks. Fluctuations in E_Z and v_R can be measured from the line separation of the π components of the H_α Motional Stark spectrum from a midplane view of emitted beam light. Linewidth fluctuations arising from plasma turbulence are expected to be $\delta E/E_{MSE} \sim 10^{-3}$. The diagnostic is comprised of two components: a low divergence ($\Omega \approx 0.5$ °), 80keV, 2.5A H^0 beam and a spectrometer designed to have high resolution, high étendue, and high sampling frequency. The beam employs a washer-stack arc ion source to maximize full energy species fraction. A novel three phase resonant converter power supply, with low ripple ($\delta V/80keV \approx 0.05\%$) at $f_{rip} \approx 280kHz$ will provide 6mA/cm^2 of full-energy H^0 at the focal plane at 80keV/amu for pulse lengths up to 15ms. Laboratory tests of the ion source demonstrate stable, repeatable plasmas with $T_e \leq 20$ eV and $n_e \approx 5x10^{17}$ m^{-3}, sufficient to sustain a 6mA/cm^2 current density at the focal plane for up to 15ms. A Spatially Heterodyned Spectrometer (SHS) satisfies the requirements of high resolution (0.25Å) and high étendue (U = 0.01cm^2-ster per spectral channel) in a compact package. The Fizeau fringe pattern produced by the SHS provides the Fourier transform of the spectrum and is recorded at high speed with a fast-framing CMOS camera (500kHz frame rate). The use of an SHS also provides built-in mitigation of the window broadening effect by imposing a compensating phase shift across the recorded spectral interferograms. Diagnostic development and validation tests will employ a helicon-generated target plasma at the DNB focal plane. Electric field fluctuations and MSE spectra can be varied on a shot to shot basis through programmable solenoid magnetic field and plate-bias.

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