Implementation of an Impurity Diagnostic Suite on the Pegasus-III Experiment

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A suite of diagnostics used to assess the impurity content and dynamics have been updated, upgraded, and installed on the Pegasus-III Experiment. Pegasus-III is a major upgrade to the Pegasus Toroidal Experiment and will serve as a testbed for non-solenoidal startup studies in the US [1]. The initial operations of the facility are focused on Local Helicity Injection (LHI) as the start-up method with typical plasma parameters of τ_{shot}~10 ms, n_e~ 1×10^{19} m^{-3}, T_e~ 50 eV. The deployed diagnostics are compatible with this modest temperature and density regime and provide species identification, source localization, and constraints on total impurity content. Hardware related to the MW class LHI system could lead to increased plasma material interaction and higher impurity influx. Efficiency of the initial plasma ramp-up can be affected by impurities because they can alter the resistivity by increasing Z_{eff} or by cooling the plasma via radiative losses. Impurity species are determined by recording time-evolving, single line-of-sight spectra at 1.2 kfps using a vacuum ultraviolet spectrometer, SPRED [2]. SPRED is equipped with a 450-g/mm grating, giving a spectral resolution of 0.2 nm and a wide spectral range from 10-110 nm, useful to identify light impurity species in this temperature and density range. An absolutely calibrated, high-throughput spectrometer collects light from the plasma at a tangency radius of 20 cm and time resolution of 2 ms and is used as a visible survey spectrometer and for continuum measurements. Radiative emission from the plasma is measured with an AXUV-based radiometer diagnostic. Two 16-photodiode arrays are placed behind pinhole apertures, resulting in 32 lines of sight at Z=0, spanning tangency radii across the whole plasma volume with a spatial resolution of 2.5 cm and 60 kHz time resolution. An absolutely calibrated collinear D_α/NIR filtered photodiode is being developed to measure the D_α emission and continuum at 1040 nm. This wavelength is chosen to avoid continuum contamination from molecular deuterium. Contributions of electron-neutral bremsstrahlung can be determined from the D_α measurements. Together with Thomson scattering measurements, Z_{eff} may then be inferred [3]. All these instruments have been designed to suppress electromagnetic interference from MW-class switching power supplies. The impurity transport code STRAHL [4] is used to interpret the diagnostic measurements and model impurity transport. Such time-evolving simulations are critical for these start-up plasmas since the particle transport time is comparable to the ionization rates meaning that impurity charge states are not in ionization equilibrium.

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