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Tokamak-Independent Software Analysis Suite for Multi-Spectral Line-Polarization MSE Diagnostics

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Tokamak-Independent Software Analysis Suite for Multi-Spectral Line-Polarization MSE Diagnostics

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A new, tokamak-independent analysis suite has been developed to process data from Motional Stark Effect diagnostics. A major feature of the system is that unlike customary MSE systems that use analog lock-in amplifiers to measure the emission amplitude at the second harmonic of the photo-elastic modulator (PEM) drive frequencies, the amplitude at many harmonics is computed using a numerical-beat algorithm. The frequency and phase of the PEM drive signal is computed very accurately by examining the successive rise-times of the drive, then reference sinusiodal waveforms are constructed at multiple harmonics. The reference waveform is numerically beat against the measured MSE signal to obtain the signal amplitudes at various PEM harmonics. The software suite encompasses four major sequenced activities: (1) computing the PEM frequency and phase; (2) computing the beam on/off timing; (3) computing the signal amplitudes at various PEM harmonics; and (4) interpolating in wavelength to accurately subtract the polarized background and computing pitch-angles. The software is modularized (~150 IDL procedures) and parallelized so that each of the 40 channels is processed independently, thereby reducing both memory requirements and processing time. The entire system including user-selected input parameters and output is based in MDSPLUS allowing straightforward porting to other tokamaks.

The availability of signal amplitudes up to the 5th PEM harmonic provides an accurate estimate of the PEM retardance. The availability of signal amplitudes at the second and fourth harmonics allows the polarization angle to be deduced from (as usual) the ratio of signal amplitudes at the second harmonic, but also from the ratio of the sum of signal amplitudes at the second and fourth harmonics; the latter approach increases the effective photon rate by 30% and is less sensitive to drift in the PEM retardance. The software also allows the polarization angles to be corrected for time-secular drift from data provided by an Intershot Calibration System, which illuminates the MSE diagnostic on Alcator C-Mod with polarized light at four known polarization angles within 10 seconds of a plasma discharge.

Finally, the software suite supports multi-spectral line-polarization MSE diagnostics which simultaneously measure emission at the MSE sigma and pi lines as well as at one or two 'background' wavelengths that are displaced from the MSE spectrum by a few nm to the red or blue, in wavelength bands carefully chosen to avoid know impurity lines. This analysis accurately estimates the amplitude of partially-polarized background light at the sigma and pi wavelengths as a function of time from measurements at the background channels, so that it may be subtracted from the total signal.

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