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Multimethod signal processing for comprehensive tune coupling characterization at Canadian Light Source

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This study compares Fast Fourier Transform (FFT), Power Spectral Density (PSD), and Wavelet Analysis for detecting tune coupling at the Canadian Light Source (CLS). Data were analyzed for low coupling, 1.4%, and 2.5% high coupling regimes, focusing on frequency identification and amplitude stability in X and Y directions. FFT revealed ˜15% amplitude fluctuations, complicating tune identification. PSD provided better stability, with only 4% amplitude variations. Both methods were computationally efficient, with FFT taking, 0.0103 seconds and PSD, 0.0108 seconds per calculation. Wavelet analysis preserved temporal-frequency relationships, revealing delays between X and Y frequencies of 2.38 to 4.77 microseconds in the 1.4% regime and peak periods around 18 microseconds. In high coupling, X frequencies preceded Y frequencies, with dominant frequencies showing higher amplitudes than perturbed ones. These findings demonstrate PSD's stability for tune measurements and Wavelet Analysis's ability to capture temporal dynamics, providing insights to enhance beam stability in accelerator systems.

Footnotes

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