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Effects of data gaps on Fourier Analysis

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Fourier Analysis is a vital and widely used tool in all branches of science that require advanced data processing. The method is often used via the Fast Fourier Transform (FFT) implementation readily available in most programming languages. This is a valid approach for data sets with equally spaced data points and no gaps. Such conditions are not always met in real situations where corrections and adjustments to the method are needed. We investigate the intrinsic limitations of four such methods when data gaps are present: 1) linear interpolations and FFT, 2) a direct implementation of the Discrete Fourier Transform, 3) a Z-Transform and 4) the Lomb-Scargle algorithm. Theoretical analysis tools can provide an insight as to the likely problems of such methods and we discuss the likely modifications to the computed spectra. Also, a time series with no data gaps and a constant sampling frequency is altered by introducing several gap configurations and the resulting spectra with the four methods are compared to highlight changes with respect to the original spectrum. Effects on the amplitude and phase of the resulting power spectral densities are analyzed for non-uniformly sampled solar wind data provided by the Venus Express spacecraft. Phase effects are also studied in the context of a sliding window approach.

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