Are the Advanced LIGO data connected? The case of GW150914 event

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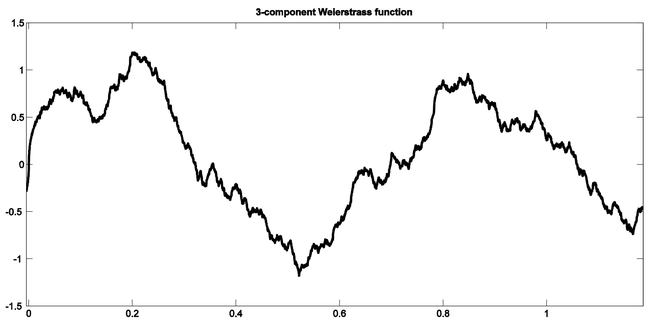
ABSTRACT
Astronomical data are generally interpreted by using harmonic analysis which relies upon the overextended paradigm of the analyticity of the underlying function. In order to tackle the problems found in the last years in the interpretation of ultra-precise data of stellar light variations observed with satellites (CoRoT, Kepler, SoHO, etc.) the authors developed an algorithm for testing the analyticity of the underlying function from which the time series constitues a discrete sample. For the cases studied so far the underlying function was not found analytic. Here we present the case of the event GW150914 as observed by the Advanced LIGO instrument. We have found that both raw and filtered data are not connected, i.e. the function underlying the sampled data is non-analytic.

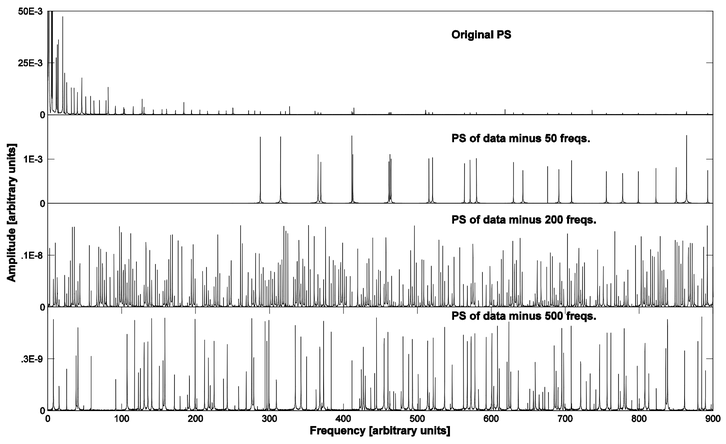
Have the underlying functions of the light curves of pulsating stars the property of analyticity?

It is only guaranteed that a function has a convergent Fourier expansion, i.e the DFT converges to the real frequency content of the time series, when the function is analytic.

Weierstrass Function

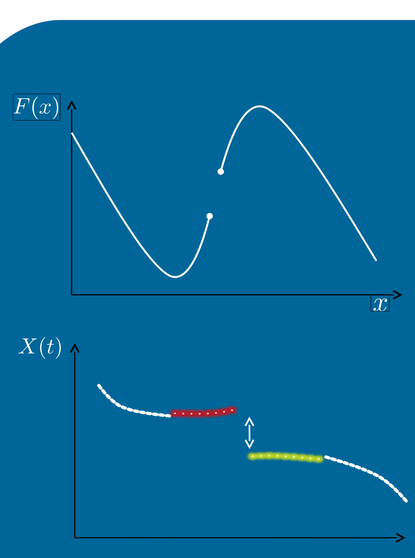
$$f(\frac{p}{q}) = \frac{\pi}{4q^2} \sum_{k=1}^{q-1} \frac{\sin(\frac{k^2 \pi p}{q})}{\sin(\frac{k\pi}{2q})}$$





An example of a non-analytic function defined as a finite sum of harmonic functions and its prewhitening cascade.

We propose to study analyticity of the underlying function of time series through the "connectivities"



Continuity

$$\lim_{x \to x_0^-} F(x) = F(x_0) = \lim_{x \to x_0^+} F(x)$$

Connectivity

$$C_n = \varepsilon_n^f - \varepsilon_n^b$$

Wiener, N. 1923, Diff. Space. J. Math. Phys., 2, 131

Backward error $\epsilon_n^b = x_n^b - x_n$

Forward error $\epsilon_n^f = x_n^f - x_n$

Connectivities $C_n = \epsilon_n^f - \epsilon_n^b$

Generalized Derivative $D_n = \frac{C_n + x_{n+1} - x_{n-1}}{2\delta t}$

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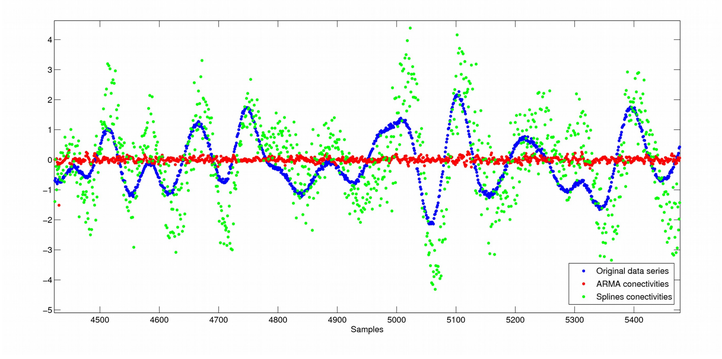


Pulsating star KIC 006187665

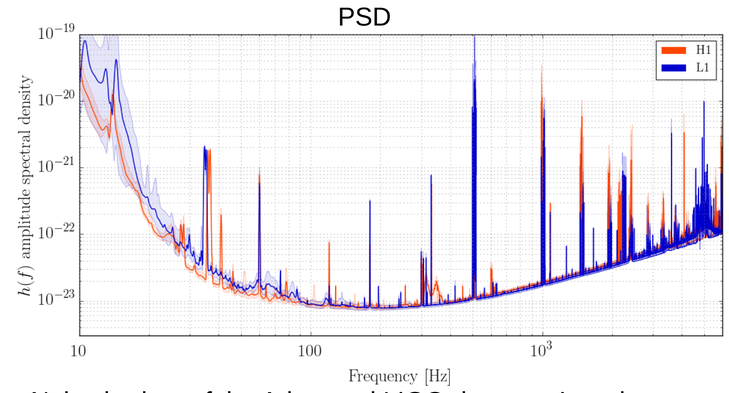
Real case corresponding to a target observed by Kepler satellite: the light curve is shown in blue, connectivities are shown as calculated by a spline fitting (analytic) in green and an ARMA model (non-analytic) in red. Notice that splines connectivities are correlated with the light curve.

Inconsistency in the application of the harmonic analysis to the stellar light curves

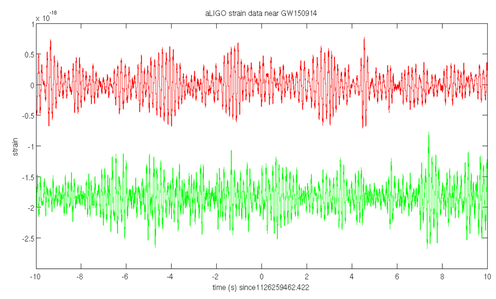
Are LIGO data connected?

Application to the case aLIGO GW150914

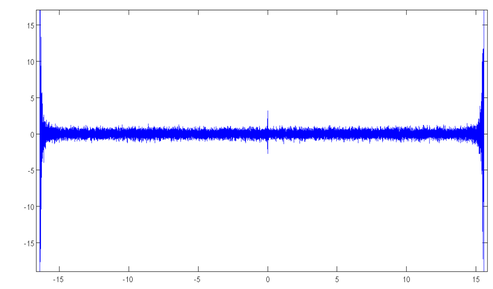
Advanced LIGO PSD



Noise budget of the Advanced LIGO detector. In order to detect the GW signal a denoising of the data is performed.



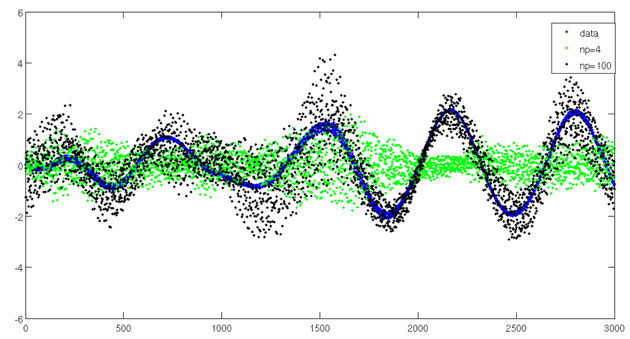
Original aLIGO strain data



Filtered aLIGO Hanford strain data

Note the dramatic effect of the filtering applied by the aLIGO team. This motivated us to apply the connectivity test.

Spline connectivities of aLIGO strain data near GW150914



Our test clearly shows that the time series of aLIGO GW150914 is not connected, therefore, the underlying function is non-analytic.

Conclusions:

1) Photometric time series of pulsating stars as observed by space satellites are not connected.
2) The time series of the data associated to the claimed detection of gravitational waves from the target LIGO GW150914 is not connected
3) We have put in question the implicit paradigm of the analyticity of the underlying function in astronomical observations. The extension of this conclusion to other fields is in progress: application to the CMB and the Allen Telescope Array data.