Empirical mode decomposition and Coloured Noise Analysis on inttime har Data

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Abstract

Here we present a method to analyse the spectral modes present in an oscillatory solar time series data, using Empirical mode decomposition technique and subsequent Coloured noise analysis for succesful detection of Quasi periodic oscillation.

Keywords : EMD, White and Coloured noise, Power Law fits, Confidence intervals

1. INTRODUCTION

We investigate the localisation of QPO in the IMFs obtained from Empirical mode decomposition. The IMFs obtained through the sifting process are generally orthonormal to a precise extent. The main oscillatory component of the signal is found to be contained in a single IMF for most non-stationary processes. Our challenge is to determine the mode containing the major oscillation using Random process analysis (2016 Kolotkov).

2. PROCESS

The original signal is decomposed into many intrinsic mode functions IMFs where each IMF contains a narrow band oscillating component. The IMFs have a decreasing content of frequencies. With the first IMF-1 having the greatest frequency and the last IMF having the least.

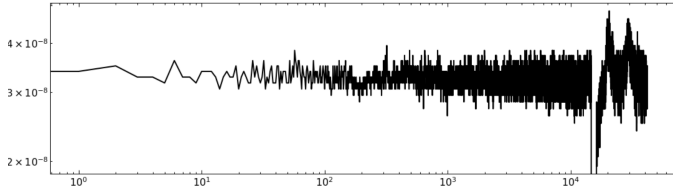Once we obtain the IMFs, we label them as; imf-i, where i denotes the ith IMF.

Fig 1: The original signal with uniform cadence.

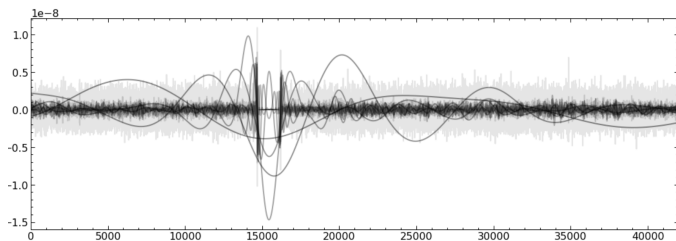After running a Masked EMD on the given signal, we obtain the IMFs

Fig 2: IMFs obtained after running through Masked IMF.

The original signal was of length 41969 samples, which was decomposed into 14 imfs. Each imfs is composed of a particular frequency range that defines the oscillations.

Below we have performed and computed the Fourier Power spectrum of each individual imf and the entire signal as shown.
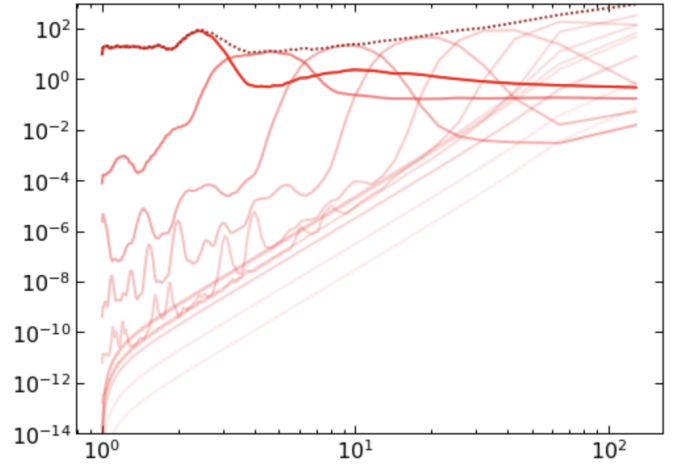

Fig 3 : Fourier spectrums of all the imfs (in red, with decreasing opacity) and the entire signal (in brown dotted lines)

Observe that the imfs till the 5th contain significant information regarding the QPP process in the solar atmosphere, however the 6th imf onwards we see that spectral density resembles a perfectly linear background noise process. And thus can be classified as a Random process.

Plotting the EMD Spectrum

The EMD spectrum is the Modal Energy of each IMF plotted against its Modal Period. The resulting plot is a set of points $(E_{m,i}, P_{m,i})$. We calculate modal energy and period of the ith imf in the following method :

$$E_{m,i} = \frac{1}{N} \sum_{k=1}^{N} imf^2_i(k) \quad ; \quad P_{m,i} = \frac{2N}{bm}$$

where b_m is the number of extrema in the IMF.