

# Time-series analysis, time-lags and Crypto-currencies

Time series analysis is a key technique that can be applied to many different areas in research, industry and finance. Among other things, time series analysis can tell us if there is a relationship between multiple apparently independent variables.

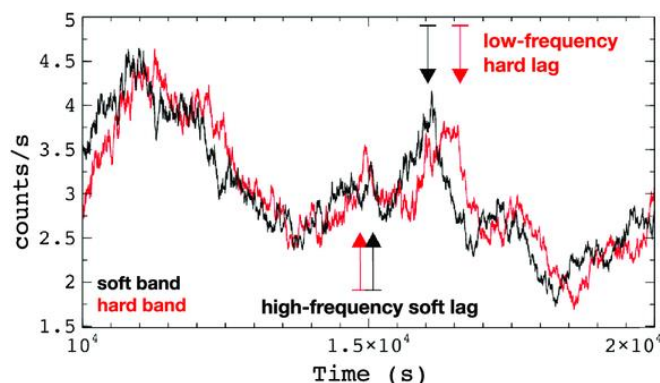
**For more information on the techniques and their power,  
watch the Lectures by Prof. Tomaso Belloni (uploaded a while ago in BB).**

For example, multi-wavelength observations of astrophysical objects show that there might be a time lag between time-series at different wavelengths (i.e. a lag between what is observed in X-rays and at Optical wavelengths). These lags, if measured precisely, can give an estimate of km size structures of point-like astrophysical objects that are too far to be spatially resolved (too far  $\gg 1^{13}$  km).

For a nice review on the subject, I recommend the student to read the review “Random time series in astronomy” by Simon Vaughan (2013, DOI: 10.1098/rsta.2011.0549) which can be downloaded from:

<https://royalsocietypublishing.org/doi/10.1098/rsta.2011.0549>

To give a graphical example, let us study the figure below:



The image is from “Reverberation mapping of active galactic nuclei: From X-ray corona to dusty torus” by Cackett et al 2021 ([https://www.cell.com/iscience/fulltext/S2589-0042\(21\)00525-3](https://www.cell.com/iscience/fulltext/S2589-0042(21)00525-3)). The figure shows two time-series, one plotted in red and one in black. Independently of what they mean, it is obvious that: (a) the two time-series are similar (but not identical) and (b) they are shifted in time, where “red” appears to lag “black”. This indicates that the two time-series are related, and the time-lag might tell us something about the physical mechanism that produces the time-series.

The problem in astronomy is that it is difficult to obtain long simultaneous observations at different wavelengths. While the study of lags is possible, it is difficult and beyond the scope of the type of projects that one can do in PHYS6017.

## PROJECT:

To understand the power of this technique, in this project the student will use publicly available data from the so-called crypto currencies. The evolution of the price of these currencies is remarkably similar to what is often observed in nature, but the datasets are completer and more homogeneous,

giving a unique opportunity to explore time lags, and dependencies. The figure below shows the price evolution of 3 crypto currencies: Bitcoin (blue), Ethereum (green) and Cardano (yellow):



As can be seen in the figure above, the 3 time-series are similar (I do not know what happened with blue on December 21<sup>st</sup>). The question is: who similar are they? Can we say that one lags the other? What is the time lag and how precise is it? Is it always there, or only in short periods of time?

In this project, the student will make use of publicly available data of different crypto-currencies. They can all be downloaded in the database: <https://www.cryptodatadownload.com/data/binance/> (We strongly suggest registering – for free – as the student can then access Hourly and Minute data). The student can choose any datasets to compare, but if there is no preference, then the 3 above (Bitcoin, Ethereum and Cardano) are already a good choice.

Sample questions to answer:

1. Are the time-series correlated? To which degree?
2. Is there an obvious lag between them?
3. Is the correlation/lag equally evident if one introduces periodic data gaps? And what about if the gaps are not periodic?

### **You do not like Finances and want to do the same project but within Astrophysics?**

If the student is not interested in doing this project given the financial background, then the student can do the exact same project by assuming that the different crypto-related time-series are actually time series of Black Holes, AGNs, or from any other astrophysical phenomena/object.

### **THE PROJECT REPORT:**

The report will have to explain the methods, the assumptions and the questions that are being answered very well. Therefore, it is recommended that the student writes as the project develops. This will make it much easier for the student, as all the content will be in the report. Now the student needs to decide what is important and relevant, and what is not.

