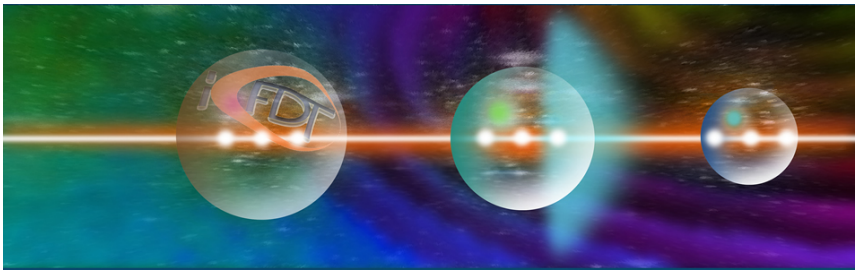

Contribution ID: **7** Type: **Talk**

Causality detection methods for time series analysis

Thursday, 4 October 2018 17:30 (20 minutes)

Coupling and synchronization are common phenomena that occur in nature, e.g. in biological, physiological and environmental systems, as well as in physics and engineered systems. Depending on the coupling strength, the systems may undergo phase synchronization, generalized synchronization, lag synchronization and complete synchronization [1]. Lag or intermittent lag synchronization, where the difference between the output of one system and the time-delayed output of a second system are asymptotically bounded, is the typical case of the fusion plasma instability control by pace-making techniques [2-3]. The major issue, in determining the efficiency of the pacing techniques, resides in the periodic or quasiperiodic nature of the plasma instabilities occurrence. After the perturbation induced by the control systems, if enough time is allowed to pass, the instabilities are bound to reoccur. Therefore, it is crucial to determine an appropriate interval over which the pacing techniques can have a real influence and an effective triggering capability.
Several independent classes of statistical indicators developed to address this issue are presented. The transfer entropy [4] is a powerful tool for measuring the causation between dynamical events. The amount of information exchanged between two systems depends not only the magnitude but also the direction of the cause-effect relation. Recurrence plots (RP) is an advanced technique of nonlinear data analysis, revealing all the times when the phase space trajectory of the dynamical system visits roughly the same area in the phase space [5]. RP refinement, called joint recurrence plots (JRPs), can be used to relate the behavior of one signal with the one of another. Convergent cross mapping (CCM) [6], tests for causation by measuring the extent to which the historical record of one time series Y values can reliably estimate states of another time series X. CCM searches for the signature of X in Y's time series by detecting whether there is a correspondence between the "library" of points, in the attractor manifold built from Y, and points in the X manifold. The two manifolds are constructed from lagged coordinates of the two time-series. The Weighted Cross Visibility Graph (WCVG) method [7] starts from the idea of mapping the coupled time series into a complex network [8] and evaluates its structural complexity by mean of the Shannon entropy of the modified adjacency matrix (constructed by weighting the connections with the metric distance between two connected values in the time series).
References:
[1] S. Boccaletti et al, Phys. Rep., 366 (2002) 1.
[2] A. Murari et al, Nucl. Fusion 56 (2016) 076008.
[3] A. Murari et al, Nucl. Fusion 57 (2017) 126057.
[4] T. Schreiber, Phys. Rev. Lett. 85 (2000) 461.
[5] N. Marwan et al, Phys. Rep. 438 (2007) 237–329
[6] G. Sugihara et al, Science 338 (2012) 496–500.
[7] A. Murari et al, Entropy 19-10 (2017) 569.
[8] S. Mehraban et al, EPL 103 (2015) 50011.

Summary

Primary author: Dr CRACIUNESCU, Teddy (National Institute for Lasers, Plasma and Raadiation Physics, Bucharest, Romania)

Co-authors: Dr MURARI, Andrea (Consorzio RFX); Dr PELUSO, Emmanuele (University of Rome Tor Vergata); Dr GELFUSA, Michela (University of Rome "Tor Vergata"); Mr LUNGARONI, Michele (Associazione EURATOM-ENEA - University of Rome "Tor Vergata", Roma, Italy); Dr GAUDIO, Pasquale (University of Rome Tor Vergata)

Presenter: Dr CRACIUNESCU, Teddy (National Institute for Lasers, Plasma and Raadiation Physics, Bucharest, Romania)

Session Classification: Data Mining