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Exploitation of Cyclostationarity and its Generalizations for Science Data Analysis

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Presentation of the main research topic related to CREDO collaboration at the University of Napoli "Parthenope" , Italy:

Exploitation of Cyclostationarity and its Generalizations for Science Data Analysis

Cyclostationarity is a statistical property of science data generated by the combination/interaction of periodic and random phenomena. These data have second- or higher-order statistical functions that are periodic functions of time. More general models can account for the presence of multiple, possibly incommensurate, and irregular periodicities ([2], Chapters 1,2). Even if the observed signals are not periodic, the hidden periodicities can be restored by estimating statistical functions from the
data. These statistical functions contain information on the generating mechanism of the data that cannot be extracted starting from the classical stationary modeling of the observed signals.

In the case of relative motion between a transmitting source and the receiver, time dilation effects must be accounted for in the received signal ([1], Chap. 6). In such a case, generalizations of cyclostationarity are appropriate models for the received signal ([1] Chaps. 2–5, [2] Chaps. 12–14).

Within the CREDO collaboration, the cyclostationary model has been exploited to confirm the main results presented in [3]. Specifically, in [3], the average variation of the cosmic ray detection rate, the earthquake sum magnitude, and the Sunspot monthly mean are shown to be pairwise jointly cyclostationary time series and the Fourier coefficients of their cross statistical functions are estimated. The results show the existence of periodic correlation or statistical dependence between pairs of these time series.

[1] A. Napolitano, Generalizations of Cyclostationary Signal Processing: Spectral Analysis and Applications. John Wiley & Sons, Ltd., IEEE Press, 2012.

[2] A. Napolitano, Cyclostationary Processes and Time Series. Theory, Applications, and Generalizations. Elsevier, 2019.

[3] P. Homola, V. Marchenko, A. Napolitano, et al. , "Observation of large scale precursor correlations between cosmic rays and earthquakes with a periodicity similar to the solar cycle", Journal of Atmospheric and Solar-Terrestrial Physics, Vol. 247, art. 106068, 2023.

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