Accelerometric nonlinearities in the International Space Station, ISS

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The aim of this work is to detect and study nonlinearities in accelerometric records from the International Space Station, ISS. These records have been obtained downloading and reading the corresponding public binary files from the NASA web[1] or using files from past experiments[2].Nonlinearities, which are the potential sources of Gaussian deviations, are detected from the digital signals themselves using higher order statistical analysis techniques[3 4].

The first nonlinearity studied is the so-called quadratic phase coupling phenomenon. In this case phase coupling between two frequency components results in a contribution at a frequency equal to their sum (difference). These additional harmonics, called distortion harmonics, are also phase coupled to the original ones. Because such coupling affects the third order cumulant, equivalently its Fourier transform, the bispectrum is the only tool to detect and characterize such kind of nonlinear effects. The detection and quantification of the quadratic phase coupling is also supported by the bicoherence index. Remember that bicoherence is a squared normalized version of the bispectrum, that is to say, computed from a single signal, the bicoherence measures the proportion of the signal energy at some bifrequency that is quadratically phase coupled.

The second kind of nonlinearity investigated here is the so-called cubic phase coupling. It appears when the frequency and the phase of a component is the sum of the frequencies and phases of the three other components of the signal. Because the bispectrum is blind to the cubically-coupling components (in the same way, the trispectrum cannot resolve quadratically-coupled components), to detect this second nonlinearity the trispectrum is mandatory.

The comparison of the results between the different signals in different positions and days enabled us to present a complete enough vibrational picture of the Station. In addition, isolation in the payload racks that can be accommodated in the European Columbus module and/or in the American Destiny Lab, more near the center of mass of the Station, will also be discussed.

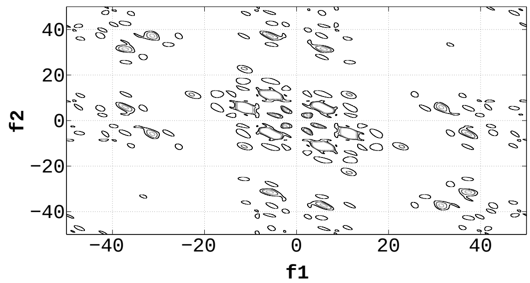

FIG. 1. Bicoherence of a real accelerometric run (number 29, start time : 08/12/09 10:40 ; end time :09/12/09 05:12) of the experiment called Influence of VIbrations on DIffusion, IVIDIL. This experiment was installed inside the Microgravity Science Glovebox, MSG, on September 23, 2009 by Frank de Winne (Expedition 21, ESA) and Robert Thirsk (Expedition 21, CSA). The experiment began October 5, 2009 and carried out more than 50 experimental runs until January 20, 2010. Finally, on January 28, 2010 IVIDIL was uninstalled by Soichi Noguchi (Expedition 22, JAXA).

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[1] http://pims.grc.nasa.gov/html/ISSAccelerationArchive.html

[2] V. Shevtsova, *IVIDIL experiment onboard the ISS*. Advances in Space Research (2010) 46, 672-679.

[3] J. M. Mendel, *Tutorial on Higher-Order Statistics (Spectra) in Signal Processing and System Theory: Theoretical Results ans Some Applications*. Proceedings of the IEEE (1991)79, 278-305.

[4] A. Swami, *HOSA, Higher Order Spectral Analysis Toolbox*, 2003, MATLAB-Toolbox.