Do you want to analyze floating structures much faster ?

Use the Multiple Timescale Spectral Analysis method !

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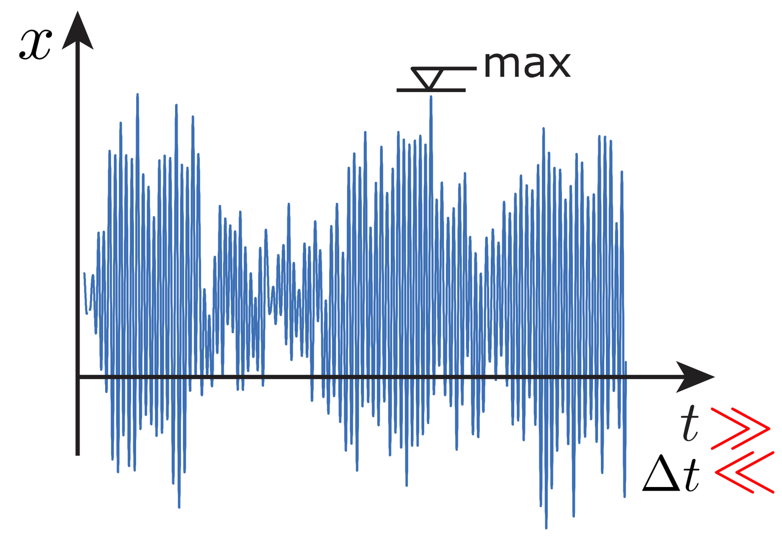
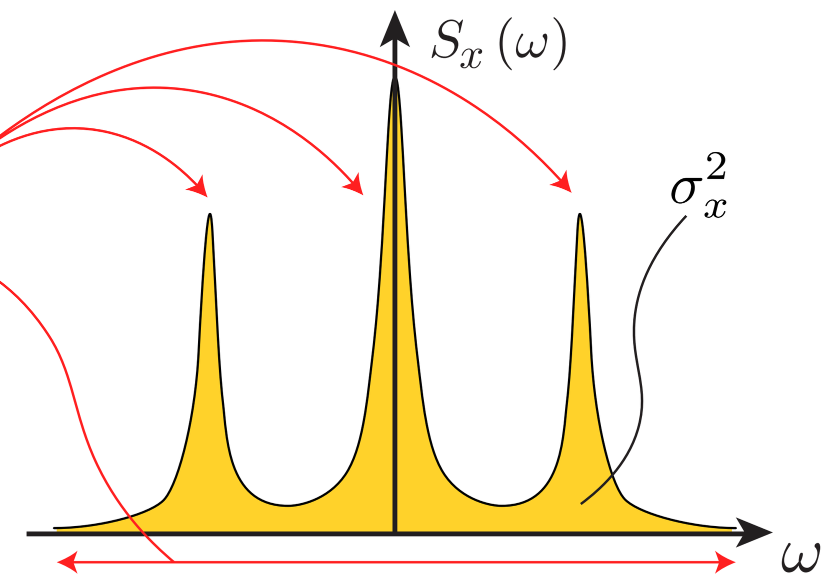
1. WHY WOULD YOU? WELL, CPU TIME IS PROHIBITIVE FOR THE MOMENT.

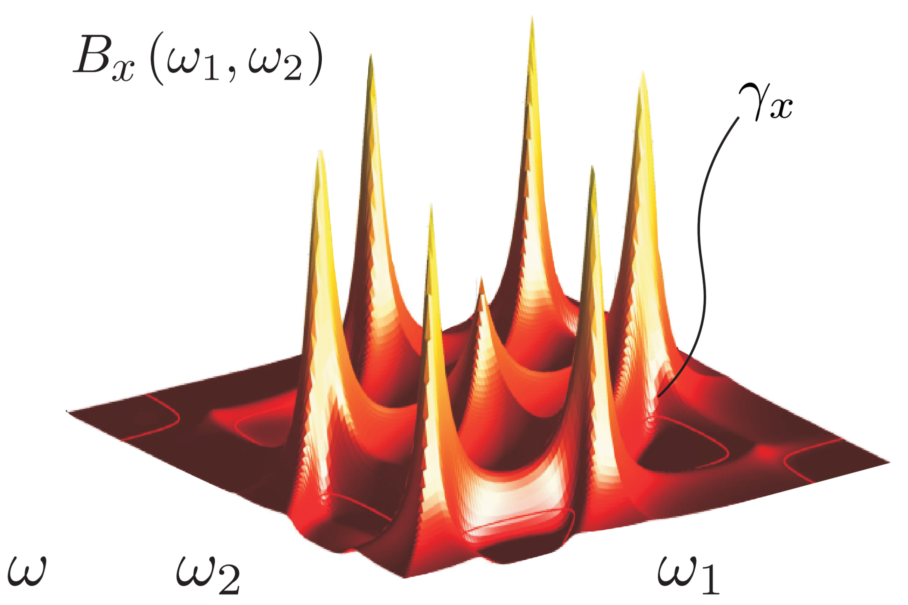
When analyzing the responses of large structures to wind and/or wave loadings, a huge number of statistics have to be computed for many configurations, erection stages, environmental conditions,... However, the traditional analysis methods, taking place in the time of in the frequency domain, are actually struggling to provide such values quickly enough because of the **clear separation** that typically exists between the characteristic timescales of the **structure** and of the **loading**.

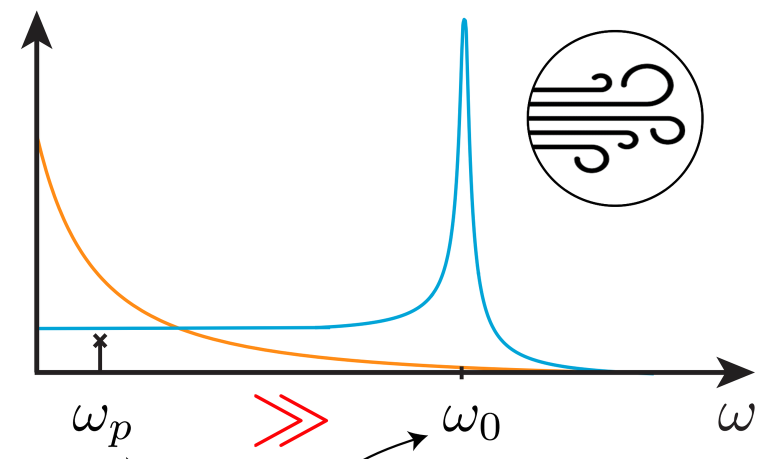


In the frequency domain, spectra are integrated
1. with closely spaced points as the peaks are sharp
2. over a wide domain since the peaks are separated

In the time domain, time series have to be simulated
1. during a long total time to observe slow variations
2. with a small time step to capture the fast dynamics

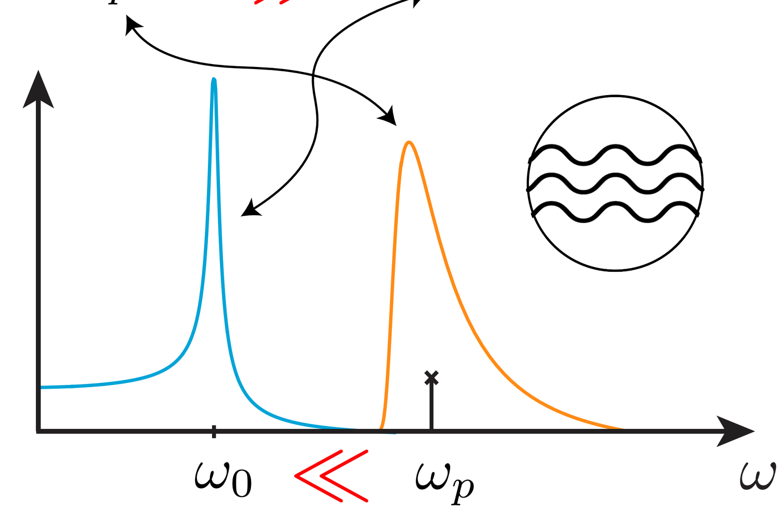






Typically, in wind-loaded «onshore» structures:
- the slow timescale comes from the loading (large eddies are hitting the structures)
- the fast timescale comes from the response (the structures are fixed to the ground)

Such structures thus respond in the background and the resonant regimes.

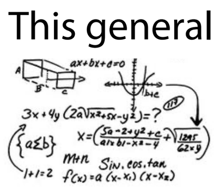


Typically, in wave-loaded «offshore» structures:
- the slow timescale comes from the response (the structures are floating on the water)
- the fast timescale comes from the response (the waves are oscillating quite rapidly)

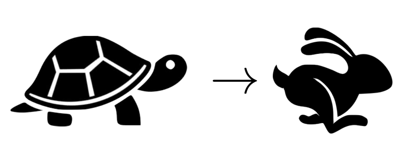
Such structures thus respond in the resonant and the inertial regimes.

2. HOW DOES THE MULTIPLE TIMESCALE SPECTRAL ANALYSIS WORK?

This general framework allows to estimate the statistics with:

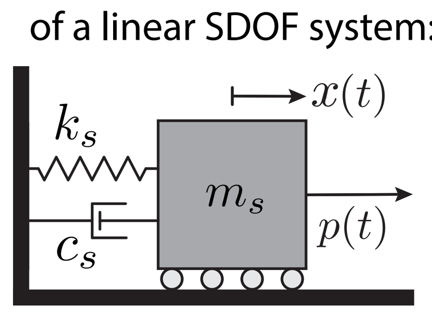


- a small and controllable discrepancy,
- a small and controllable discrepancy, $\mathrm{ord}(\xi, \alpha)$
- a very large reduction of the CPU time (x 100)



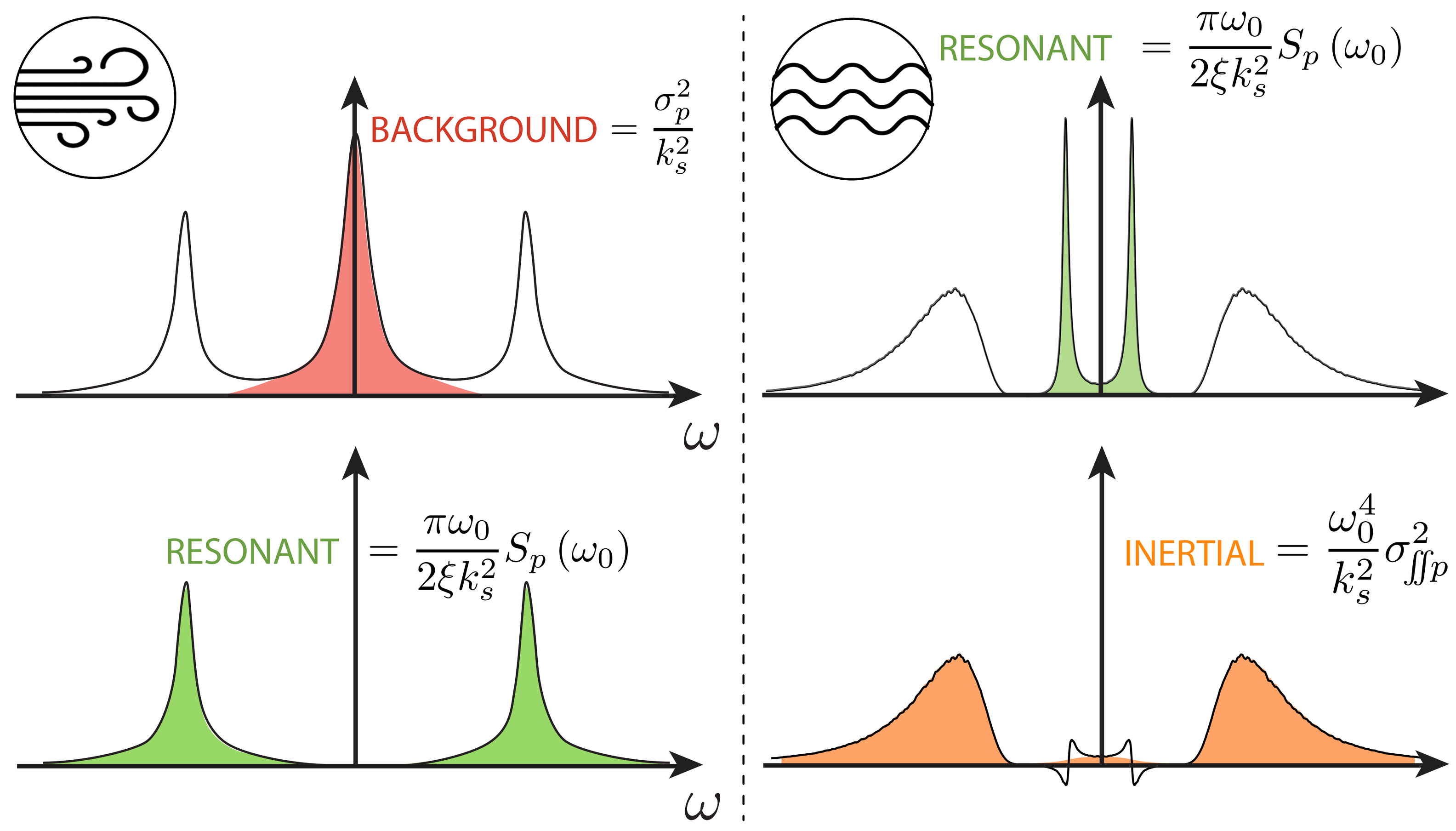
The Multiple Timescale Spectral Analysis method hinges on the perturbation theory to take advantage of the separation of timescales. Indeed, if the peaks of the spectra are separated, their contributions can be considered one after the other by
1. locating the position of the main component,
2. focusing on it by using a stretched coordinate,
3. finding a local and integrable approximation,
4. subtracting it to form a new residual function.

Variance of the response of a linear SDOF system:



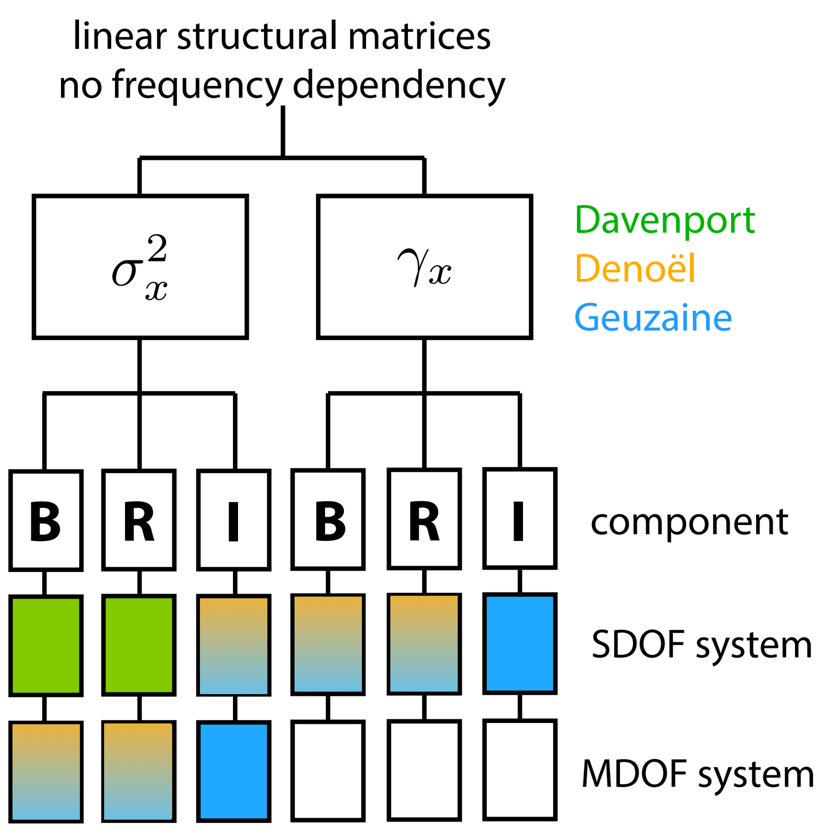
$$\omega_0 = \sqrt{\frac{k_s}{m_s}}$$

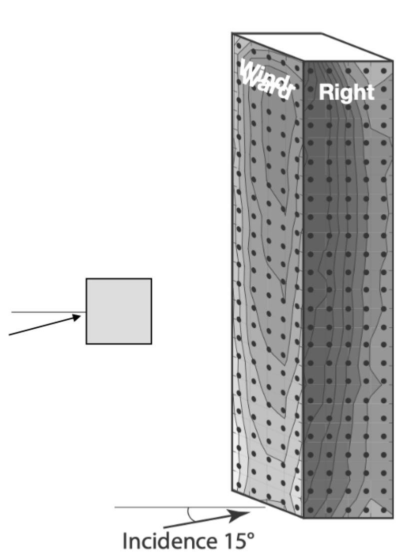
$$1 \gg \xi = \frac{c_s}{2 m_s \omega_0}$$

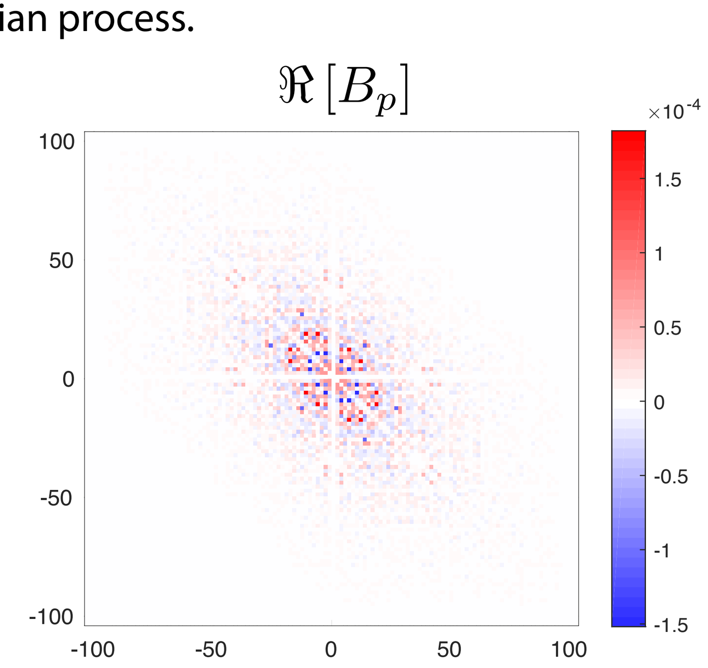


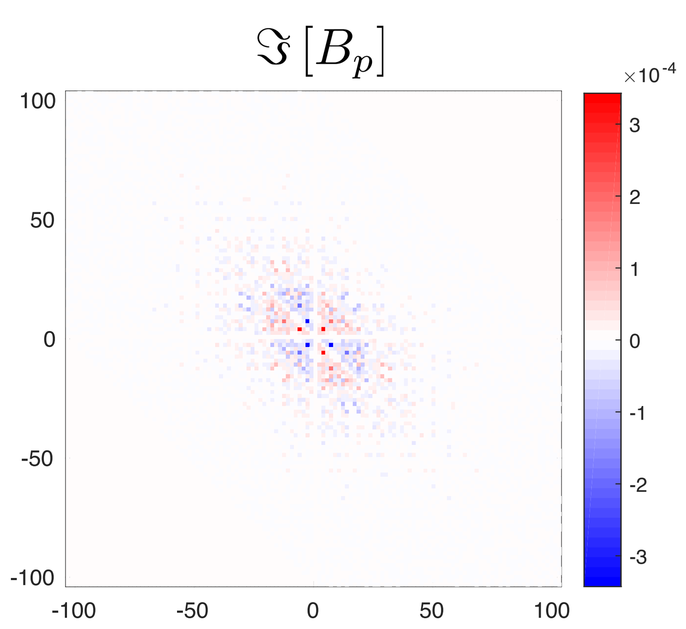
3. WHAT IS AVAILABLE FOR NOW? AND WHAT IS STILL MISSING?

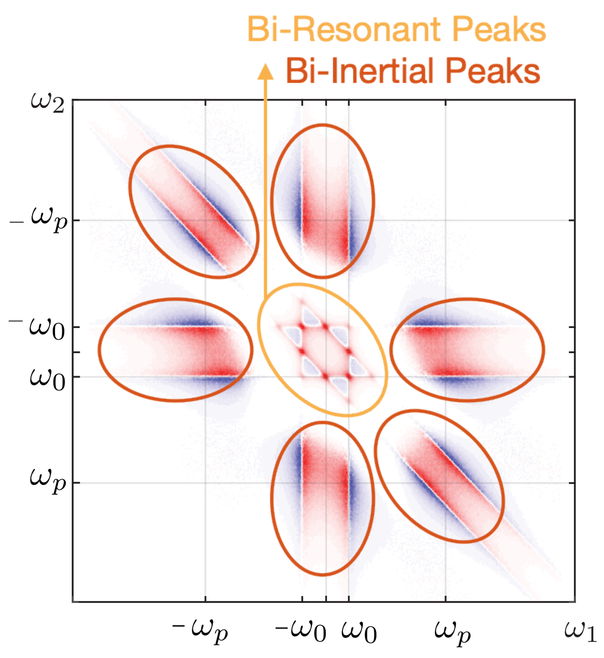
As shown above, the Multiple Timescale Spectral Analysis has already been used to get the inertial component of the variance of a linear SDOF system. When an oscillator is subjected to a non-Gaussian loading, higher order statistics, such as the skewness, are needed to get a complete probabilistic description of the response. The bi-inertial component of the skewness has thus been expressed by using the proposed method as well. An additional part has also been developed for completing the bi-resonant component when the bispectrum of the loading is complex. In particular, this is the case when the pressure signals are not related to the polynomial transformation of a Gaussian process.











The inertial components of the modal covariances are currently developed in order to tackle the analysis of structures with many degrees of freedom. Last step will consist in taking the frequency dependency of the structural matrices into account as well because it influences the response when the motions of the fluid and the structure interact.

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