Control mechanism of phase synchronisation in oscillators of different kind: experimental results

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In this contribution, we present experimental results on a novel mechanism for controlling the phase synchronisation of coupled oscillators. In a recent paper, Belykh *et al.* [1] presented a feedback control method for automatic phase-locking of regular and chaotic oscillators. Interestingly enough, this method allows for synchronisation among oscillators of different kind. In the particular set-up considered in our work, we consider a chaotic oscillator (Rössler) and a regular (van der Pol) one. Within this setting, one acts as a *master unit*, while the other is the *slave*. The feedback mechanism is implemented in the following way: a multiplier works as a correlator between two variables of the dynamical systems. This mechanism acts separating the sum of the frequencies of both variables and the difference. Only in the case of perfect phase synchronisation (frequency difference equal to zero) the feedback mechanism does not contribute to the dynamics.

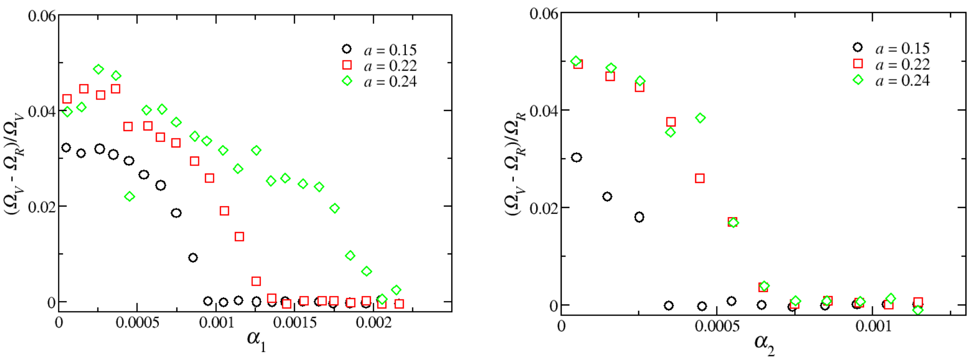

Figure 1: We plot the measured frequency difference as a function of feedback strength between the electronic implementations of a van der Pol and Rössler oscillators. The different plots show the former acting as a master (left panel), while the right panel depicts the results when this role is played by the Rössler. It is observed that the driven unit can synchronise to the controller one due to the feedback mechanism above a critical interaction strength.

We have designed electronic implementations of Rössler and van der Pol oscillators, and coupled them directionally through the feedback mechanism described above. We have experimentally verified that this mechanism can effectively control the

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synchronisation of both units, even though they have different inherent dynamic properties. Figure 1 depicts the experimental results, showing phase synchronisation above a value of feedback strength.

It is of particular interest for practical implementations also to consider alternative control mechanisms, that might be more robust to changes in the working conditions. With this aim, we replaced the feedback mechanism for a *fuzzy* controller. We found that phase synchronisation to master's frequency is also achieved.

References:

[1] V.N. Belykh, G.V. Osipov, N. Kuckländer, B. Blasius, J. Kurths, *Physica D*, **200** 81 (2005).