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Forced Oscillations in Self-Oscillating Surface Reaction Models

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1 Introduction

Harmonic resonance, subharmonic and superharmonic entrainment, quasiperiodic and chaotic behavior are well known to occur in nonlinear self-oscillating systems which are subject to periodic forcing. Harmonic resonance occurs if the periodic forcing signal has a frequency very similar to the one of the undisturbed system and results in an amplification of the oscillations.
The resonance properties of two physically distinct self-oscillating surface reaction models are considered by means of Monte Carlo and Cellular Automaton computer simulations. It is shown that the qualitative resonance properties are insensitive to the details of a particular model. Moreover, both models have different mechanisms of oscillation synchronization.

2 Self-oscillating surface reaction models

The first model is a Lotka-type A+B->2B reaction, which is the simplest heterogeneous catalytic reaction introduced by Mai et al [1]. Both reactants A,B are *immobile* (no diffusion), but oscillations are caused by percolation type mechanism. It is demonstrated that the periodic variations of reactant adsorption rate lead to the resonance effects. The Lotka-type model shows subharmonic, harmonic and superharmonic resonaces, when the ratio modulation vs systems frequencies are 1:2, 1:1, and 2:1, respectively [2].
The second model describes the catalytic *diffusion-controlled* $CO+1/2O_2$ reaction on Pt(110) surface [3]. It accounts for all CO oxidation microscopic steps including surface reconstruction. This microscopical model is able to explain some of the most important experimental results for both surfaces, Pt(100) and Pt(110), such as critical coverages [4], local oscillations and pattern formation [5], global synchronization mechanisms [5,6], and the resulting transition into the limit cycle .
This model besides already mentioned resonances demonstrates a phase locking at ratio 2/3. Additionally, a number of entrainments were observed. This self-consistent stochastic model correctly describes experimentally observed resonance phenomena without using any parameters taken from experiment. The reaction has been investigated

in great detail (for a review see ref. [7]) and especially the behavior under periodic forcing has been experimentally studied about 10 years ago by Eiswirth and Ertl [8]. In this study all the above mentioned resonance phenomena could be observed with the exception of chaos because of limited experimental resolution. In fig. 1 a timeseries of the superharmonic 5/3 entrainment is shown as an example.

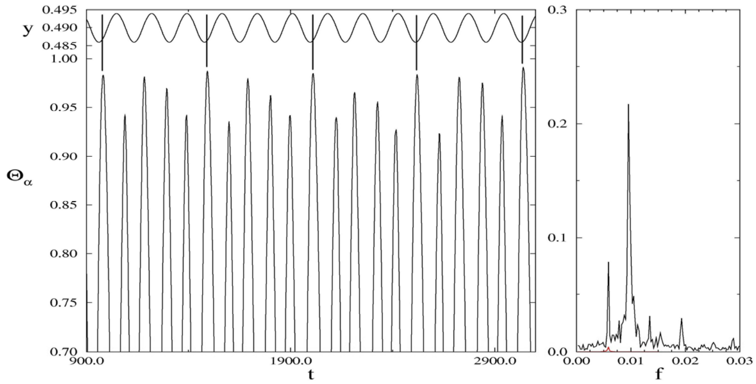

Fig. 1: Time series and power spectrum of 5/3 superharmonic entrainment.

3 Conclusion

A comparison of both models indicates that the basic resonance properties for different catalytic reactions are qualitatively similar. However, the quantitative properties, such as particular resonance frequencies and entrainment frequencies depend on system's microscopic model definitions.

References

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