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Referee Report on the PhD thesis

Synchronization of Coupled Spherical Pendula

by

Blazej Witkowski

Blazej Witkowski intends in this thesis to study synchronization regimes of coupled spherical pendula. Although this looks like a classic problem, it is one of high actuality. Here already a main problem occurs in modelling such a system. So far mostly planar or rotating pendula have been studied. Therefore this is a very difficult problem, which could offer new perspectives for further research in nonlinear dynamics as well as its application to various fields.

The thesis is subdivided into two main parts: first an introduction and overview and second two papers of the candidate which were already published in well-known peer-reviewed journals.

Part 1 starts with a concise but instructive introduction to some basic motivation and the main objectives of this work. Then a very short methodology is given. The candidate starts with experimental observations. This is very important. Unfortunately, he has not explained the main results of his experiments, in particular Figs. 2.1.3 – 6 are not referred to in the text. The same with Fig. 2.1.1. Already then some remarks on the numerical analysis are presented before giving any model. But then in more detail a description of the main mathematical model, the methods used and the main results are given. Here the own contributions of the candidate become very clear. Finally the main conclusions as well as an interesting outlook to future work are presented.

This part is very important for the understanding of the whole thesis. The English, in particular the use of articles, should be improved. Now it is sometimes a bit difficult to understand.
The two papers are very well written and here all intentions, methods and results are clearly presented.

It is very important to emphasize that Blazej Witkowski compares different approaches to model this coupled system with real experiments. This way he selects the model which best describes the experimental findings for a deep theoretical and numerical analysis. He starts with an approximation for the case of small amplitudes, but goes beyond this rather strong restriction by originally using the Newton-Raphson algorithm. Then he finds important solutions for different regimes of synchronization. The candidate studies constant as well as harmonic excitations and shows clearly their different influences on the system´s behaviour.

The analytical and numerical analysis is very deep, and there is some originality in the modelling vs. experiments and the extension to large

amplitudes. The experimental, analytical and numerical work is very thoroughly performed. The results obtained are a substantial contribution to this field of research and I expect a long-standing impact for further theoretical as well as experimental studies.

Therefore, I very strongly recommend to accept the thesis of Blazej Witkowski.

However, I have some questions and recommendations which should be clarified or discussed :

- How was the comparison experimental results vs. modelling performed, more qualitatively or even quantitatively?
- Which further experiments could be performed?
- Are there some specific applications of this approach doable?
- So far only identical systems have been studied. What about non-identical ones ? Which new phenomena are to be expected?
- There are some further interesting open points given in chapter 5. They should be explained in more detail.
- How the accuracy of the approximation in the large amplitude case was tested. How to improve this?

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