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P I K

Potsdam Institute for Climate Impact Research. P.O. Box 60 12 03 D-14412 Potsdam

Potsdam Institute for Climate Impact Research

P.O. Box 60 12 03
14412 Potsdam | Germany
Phone +49 331 288 2500
Fax +49 331 288 2600
www.pik-potsdam.de

Institute of the Leibniz Association

Director:
Professor H. J. Schellnhuber CBE

Bank Account:
Mittelbrandenburgische
Sparkasse Potsdam (MBS)
IBAN DE69 1605 0000 3502 2355 29
Swift-Code WELAD1DEPMB

Potsdam, 13.09.2017

Prof. Dr. Dr. h.c. mult. Jürgen Kurths
Head of Research Domain
Transdisciplinary Concepts and Methods
fon +49 (0)331 - 288 - 2647
fax +49 (0)331 - 288 - 2600
kurths@pik-potsdam.de

Referee Report on the PhD thesis

Revealing different kinds of chimera states in the systems of coupled pendula

By

Patrycja Jaros

Patrycja Jaros intends in this thesis to study a special form of complex behaviour, chimera states in pendula coupled through springs. This is a very difficult problem of high actuality and importance.

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

journals. It is very important to emphasize that Patrycja Jaros is the first author in three of these 5 papers!

Part 1 starts with a pregnant but instructive introduction to basic concepts as well as knowledge about chimera states in theory and experiments.

The candidate summarizes in part 2 her main own results. Finally the main conclusions as well as a very short but interesting outlook to future work are presented.

To her main results :

Paper 1 studies the classic Kuramoto model but with inertia which is very important for various applications, especially power grids. Based on a very thorough analysis she uncovers there an imperfect chimera state and she also finds the mechanism of its occurrence via solitary states. This is a very important approach for understanding of such complex regimes which are at the transition from coherence to incoherence.

In paper 2 the following important problem will be solved : how many units are at least necessary for the existence of chimera. The authors find that 3 coupled pendulum nodes, again in the form of Kuramoto with inertia, are sufficient to observe chimera. This study includes a detailed bifurcation analysis for exhibiting the mechanism of such a weak chimera.

In paper 3 (what is the stae of it ???) Patrycja Jaros is looking for another basic phenomenon : solitary states. She uncovers that different types of these states do exist in oscillators under various coupling regimes. They appear via a homoclinic bifurcation and are typical for such coupled systems. In contrast to chimeras, these solitary states are long-term stable.

In paper 4 imperfect chimera states are found experimentally in coupled metronomes (pendula). This is a newly discovered special state which should be crucial for various other applications. The experiments are additionally well described by a mathematical model which is based on Newton´s laws.

In the final paper 5, Patrycja Jaros and coauthors analyse multi-headed chimera states , again in coupled pendula. The existence of these states are clearly shown in such a system and the dynamics of the pendula are discussed in detail for a network of 50 pendula.

To summarize : Patrycja Jaros has presented a very substantial thesis with a lot of important results on the formation and existence of several chimera states in coupled pendula. She has found the minimum number of units necessary for the occurrence of chimera and has uncovered new types, in particular imperfect chimera. This new type has been found experimentally as well as theoretically. Additionally, she has uncovered solitary states in such systems; they are very important for many other systems as well.

I expect a strong impact of her results.

Therefore, I very strongly recommend to accept the thesis of Patrycja Jaros.

Jürgen Kurths

Full Professor of Physics, Humboldt-University Berlin and
Chair of the Research Domain Transdisciplinary Methods at the
Potsdam Institute for Climate Impact Research, Germany

Fellow of the American Physical Society
Member of the Academia Europaea