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Synchronization

Review of *Synchronization: A universal concept in nonlinear science*, by A. Pikovsky, M. Rosenblum and M. Kurths, Cambridge University Press, 2001.

While lying sick in bed for a couple of days during 1665, the distinguished Dutch scientist Christiaan Huygens was astonished to observe "...a wonderful effect that nobody could have thought of before". The pendula of two clocks in the room seemed to be swinging in exact antiphase: when one pendulum swung to the right, the other swung to the left, and vice versa. Furthermore, their synchronization continued for as long as his patience lasted, making it extremely unlikely that the effect could have arisen by chance. He quickly realised that the "eternal agreement" of the clocks was attributable to a weak coupling, through their being mounted on the same beam: the movement of one pendulum infinitesimally moved the beam, and thus the other clock. The interaction of the two oscillations, although extremely weak, was sufficient to bring about their synchronization.

Over the ensuing centuries it has become clear that synchronization by no means restricted to swinging pendula, nor even to mechanical systems. Rather, it is a quite general phenomenon that can arise in innumerable different situations including, for example, electronic circuits, adjacent organ pipes (which can almost silence each other by resonating in antiphase), lasers, the light pulses emitted by clouds of fireflies, and flocks of flying birds flapping their wings in synchrony.

How does one define synchronization? The authors take synchronization to be an *adjustment of rhythms of oscillating objects due to their weak interaction.* Of course, where the interaction is not weak, the notion of synchronization no longer makes any sense because there is then only a single unified system. The oscillations of the separate subsystems must also be self-sustained. Thus the population oscillations in the famous hare-lynx system do not represent synchronization because neither population would separately oscillate. In true synchronization, the adjustment of rhythms occurs for a restricted range of frequency mismatch within which, if the frequency of one oscillator is slowly varied, the second oscillator will be constrained to follow.

Synchronization phenomena are important in a myriad of different ways. One topical example is the Millennium Bridge in London, where the steps taken by pedestrians were effectively synchronized by the "global coupling" provided by the weak oscillatory response of the bridge to their feet – leading to large and potentially dangerous excursions. (The bridge had to remain closed for several months while damping systems were incorporated.)

Another example is the mammalian cardio-respiratory system, where episodes of synchronization occur between breathing and heart beat. The lengths of these episodes seem to be associated with the state of the system, being longer in athletes than sedentary individuals and completely absent in a patient in coma. Recent evidence has emerged linking the synchronization number (i.e. the number of heartbeats per breath) during anæsthesia to the depth of anæsthesia – which could obviously have useful applications.

The authors have attempted to provide a definitive account of synchronization that is accessible on many levels. They address the wide audience of scientists that are likely to the interested, taking explicit account of their differing levels of mathematical preparation. The book is in three parts. Following the Introduction, there are five chapters treating the subject with a minimum of mathematics. They concentrate on the basic physical concepts, supported by diagrams, graphs, and only the most basic of equations. This part should be comprehensible to anybody willing to read the text carefully, study the diagrams, and think. The six chapters forming the second part treat classical syncronization in all its aspects, including large populations of globally coupled oscillators such as the light-emitting fireflies mentioned above. Part III consists of three chapters that treat the forms of synchronization that are now known to arise in systems exhibiting deterministic chaos. The appendices include translations from French and Latin of some of Huygens' historic writings, which are apposite and extremely interesting, as well as some more formal mathematical material.

Have the authors succeeded in their aims? They certainly have, in my opinion. Their book has all the hallmarks of a classic. It is currently unique, the first attempt to cover synchronization phenomena in a comprehensive and unified way in English. By drawing together many different threads from diverse areas of science, and weaving them into a coherent whole, they come close to identifying a new scientific subject – or, at least, to conferring respectability on a subject that was already starting to emerge. They have presented it in a comprehensible and interesting way, but with full mathematical detail for those who need it, and provided an extensive bibliography. Every scientist working in the area will want a copy of this book, and every science librarian should buy one. No doubt it will run through many editions, and deservedly.

P.V.E. McClintock
(Lancaster University)

The Cambridge Nonlinear Science Series contains books on all aspects of contemporary research in classical and quantum nonlinear dynamics, both deterministic and nondeterministic, at the level of graduate text and monograph. The intention is to have an approximately equal blend of experimental and theoretical works, with the emphasis in the latter on testable results.Â Lattice gas hydrodynamics. A. Pikovsky, M. Rosenblum and J. Kurths 12. Synchronization â€“ a universal concept in nonlinear sciences. Synchronization. A universal concept in nonlinear sciences. Arkady Pikovsky, Michael Rosenblum and JÃ¼rgen Kurths University of Potsdam, Germany. Cambridge, New York, Melbourne, Madrid, Cape Town, Singapore, SÃ£o Paulo. Synchronization an universal concept in nonlinear sciences. Cambridge University Press.Google Scholar. 40.Â A theory for synchronization of dynamical systems. Communications in Nonlinear Science and Numerical Simulation, 14, 1901â€“1951.MathSciNetzbMATHCrossRefGoogle Scholar. 43. Vaidyanathan, S., & Azar, A. T. (2015). Start by marking â€œSynchronization: A Universal Concept in Nonlinear Sciences (Cambridge Nonlinear Science Series Book 12)â€ as Want to Read: Want to Read savingâ€¦ Want to Read.Â These phenomena are universal and can be understood within a common framework based on First recognized in 1665 by Christiaan Huygens, synchronization phenomena are abundant in science, nature, engineering and social life. Systems as diverse as clocks, singing crickets, cardiac pacemakers, firing neurons and applauding audiences exhibit a tendency to operate in synchrony. These phenomena are universal and can be understood within a common framework based on modern nonlinear dynamics. Request PDF | Synchronization: A Universal Concept In Nonlinear Sciences | Preface 1. Introduction Part I. Synchronization Without Formulae: 2. Basic notions: the self-sustained oscillator and its phase 3. Synchronization | Find, read and cite all the research you need on ResearchGate.Â Understanding these global dynamical behaviour exhibited by a network of coupled oscillators has been a topic of extensive research in many fields of science and engineering. Various factors govern the resulting dynamical behaviour of such networks, including the number of oscillators and the coupling schemes between them.