Abstract of Gokul PM's Doctoral Thesis

In this Doctoral Thesis the concept of synchronization of systems with complex dynamics has been discussed. Different types of scenarios, including multistable systems with hidden and rare attractors have been studied, showing that observed phenomena can be found in variety of models, especially fundamental ones from the field of mechanical systems. The Dissertation includes results from four publications, which short summaries are given as follows.

In the first paper a modified Sprott systems that show multistability with one hidden attractor have been studied. Two types of coupling schemes have been used to connect different states, which highly depend on initial conditions, leading to possibility of systems to synchronize. The dependence between structure of the coupling and final synchronized attractor has been discussed, especially taking into account the initial problem of starting of both systems from the hidden state's basin.

Then, the model of coupled Kuramoto oscillators with single strongly attractively coupled external oscillator has been studied. Multiple regions of synchronization, that has not been observed using standard Ott-Antonsen method of analysis have been determined and analyzed using typical distributions of the oscillators' frequencies (just to mention Gaussian or Lorentzian ones). Moreover, the influence of three parameters of considered system on observed patterns and their dynamics have been described, i.e. the internal coupling strength, the external forcing strength and the difference between the average internal and external frequencies.

In the third publication the problem of master-slave synchronization of discrete dynamical units has been considered. A simple systems with two symmetries, i.e. local and global have been chosen and coupled through a wreath product coupling. The behavior and properties of model have been studied and typical synchronization patterns have been described. It has been shown that apart from typical scenarios like in- or anti-phase synchronization (which highly depends on the suitable choice of coupling) also mixed synchronization can be obtained, which interestingly does not require any parametric tuning. Moreover, chaotic behavior of model has been reported and verified using Lyaponov exponents.

In the last paper a three-dimensional chaotic system with an infinite number of equilibria has been studied. Different properties of considered model have been analyzed using typical tools of nonlinear dynamics, just to mention phase portraits, Poincare sections or bifurcation diagrams. It has been shown that although the system has infinitely many fixed points, it can exhibit co-existing non-trivial attractors. Chaotic synchronization of proposed model has been investigated using adaptive control method. Additionally, the fractional-order form of considered system has been introduced and studied.

Results presented in this Dissertation exhibit that in models of coupled systems with complex dynamical properties synchronization can occur and different types of synchronized patterns can be observed. It has been shown that when oscillators possess hidden attractors, variety of synchronization scenarios is possible, which proves the Thesis of the Doctorate. Systems

considered in this study represent fundamental examples of models with complex, multistable dynamics. Taking into account obtained results and their universality, one can expect that discussed phenomena can be observed also in typical mechanical systems having similar, dynamical properties.

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