MECHANICAL ENGINEERING STUDENT SEMINAR

Thursday, August 18 2022 at 11:00
Online: https://technion.zoom.us/j/96326122392

Bifurcations and chimera states in a self-excited inertia wheel double pendulum array

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Self-excited synchronous oscillations in multibody dynamical systems have been documented since the middle of the seventeenth century. Huygens made the amazing observation that two pendulum clocks hanging from a common flexible support swung together periodically approaching and receding in opposite motions. During the last two decades there has been a growing interest in the stability and robustness of continuous and intermittent synchronization of periodic and nonstationary oscillations which have been observed in neural network populations and in experiments of mechanical networks. Of particular interest are the chimera states in which the symmetry of an oscillator population is broken into a synchronous part and an asynchronous part culminating with a novel class of decoherent behavior.
In the present research we investigate the emergence of bifurcations and chimera states in a self-excited inertia wheel double pendulum array. We consistently model an array of inertia wheel double pendula where the onset of self-excited oscillations is governed by feedback of the augmented inertia wheels. A combined analytical and numerical approach is employed to investigate the dynamical system bifurcation structure. An asymptotic multiple-scales analysis yields conditions for existence of in-phase solutions in a weakly nonlinear configuration, whereas a computational bifurcation analysis reveals both synchronous and decoherent states in both oscillation and rotation regimes for a strongly nonlinear configuration. The bifurcation structure includes in-phase and anti-phase states of periodic oscillations and both chimera and decoherent states for emerging chaotic and nonstationary oscillations. The significance of the research is twofold. First, the combined analytical and numerical methodologies enable identification of stability thresholds for both weakly and strongly nonlinear ranges of operation. Second, the combined methodologies enable construction of a comprehensive nonlinear bifurcation structure that shed light on emergence of chimera states, synchronization and decoherence in a double pendulum array, where inertia wheel feedback does not require the use of phenomenological modeling of the governing self-excited dynamics.

Note: the seminar will be given in Hebrew

Seminars Coordinator: Assoc. Prof. Matthew Suss.