INVESTIGATION INTO COMPLEX SYSTEMS

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SYLLABUS

• Introduction to Complexity: Natural Complexity and Computational Complexity.

• The Second Law of Thermodynamics: entropy and the arrow of time.

• Violation of the Second Law of Thermodynamics: "Gedanken Experiments" and The Fluctuation Theorem.

• The principles of the Non-Equilibrium Thermodynamics. Flows and Forces. The Linear and Non-linear regimes. Entropy production and evolution criteria for out-of-equilibrium systems.

• Linear stability analysis of stationary states: stable, unstable, and oscillatory states.

• Non-linear dynamics and Bifurcations.

• Oscillatory Chemical Reactions, Chemical Waves, Turing structures and Periodic Precipitation.

• More insight into the Non-linear regime: Bifurcations and Chaos.

• Chaos in space: Fractals.

• Strategies to face the challenges of XXI Century Challenges that regard Complex Systems, Computational and Bio-ethical Complexity.

The course includes laboratory experiments. Examples are:

(1) ORDER IN TIME: The chemiluminescent oscillatory Orban reaction.

(2) ORDER IN SPACE: Comparing patterns generated by the Belousov-Zhabotinsky reaction and the periodic precipitation.

(3) CHAOS: Photochemical hydrodynamic oscillator.

(4) CHAOS AND COMPLEXITY: Computational experience by using the NetLogo software.

TEXTBOOK:

P. L. Gentili, "Untangling Complex Systems: A Grand Challenge for Science", CRC Press (FL, USA), 2018.