Nonlinear Dynamical Aspects of Electrochemical Systems
001-2-4049 (3 credits)

Prof. Arik Yochelis

The course is planned to lay dynamical systems foundations and to extend the standard (and old) knowledge of electrochemical systems towards modern applications.

Prerequisite: Basic Calculus, Basic Chemistry, Introduction to Ordinary and Partial Differential Equation.

Lectures/Exercises/Credit: 3 weekly lecture hours, 3 credit points.

Syllabus:

- **Electrochemistry**
- Fundamental electrochemical concepts, such as over-potential, charge transfer, (non) Faradaic reactions, thermodynamics, kinetics, electrical diffuse layer, etc. .
- Theory of mass and charge transport in a fluid medium.
- Charge transfer at the fluid-solid interface: reversible and irreversible reactions.
- Charge dynamics in non- aqueous oil-water-surfactant media.
- Introduction to dynamical systems.
- Electrochemical oscillations and non-monotonic I-V relations.
- Empirical methods: potential step, potential sweep, thin layer electrochemistry, rotating disk electrode, impedance spectroscopy.
- Numerical methods and simulations.

Applications

- Bulk heterojunction photovoltaics, such as excitonic (organic) solar cells.
- Ionic liquids.
- Flow batteries.
- Colloidal systems.

Bibliography:

- Electrochemical methods. Fundamentals and applications, Bard and Faulkner - Wiley, 2001
- Fundamentals of electrochemistry, Bagotsky -John Wiley & Sons, 2006
- Impedance Spectroscopy, Barsoukov & Macdonald, John Wiley & Sons, 2005

- Redox flow batteries: a review, Weber et al, J Appl Electrochem 2011 41, 1137
- Comparing organic to inorganic photovoltaic cells: Theory, experiment, and simulation, Gregg & Hanna, J. Appl. Phys. 2003, 93, 15
- On the Morphology of Polymer-Based Photovoltaics, Liu et al, Journal Of Polymer Science Part B: Polymer Physics 2012, 50, 1018
- Charge transport and current in non-polar liquids, Neyts et al, J. Phys.: Condens. Matter 2010, 22, 494108
- Intensive current transfer in membrane systems: Modelling, mechanisms and application in electrodialysis, Nikonenko et al, Advances in Colloid and Interface Science (2010), 160, 101
- Fronts, Waves, and Stationary Patterns in Electrochemical Systems, Krischer et al, Angew. Chem. Int. Ed. 2001, 40, 850
- Self-organization phenomena at semiconductor electrodes, Foll et al, Electrochimica Acta 2009, 55, 327

Grade: midterm project (40%), final project + formal presentation of the project (60%).