Research interests
The group focuses on pattern formation in far from equilibrium physicochemical systems, with an emphasis on renewable energy and biological media. The research is multidisciplinary and ranges from basic theory, such as local and global bifurcation theory, to applications-driven, such as intra-cellular actin polymerization, localized waves in the inner ear, soft-matter energy devices where morphology is coupled to Coulombic interactions, and photo-electrochemical water splitting at semiconductor/electrolyte interfaces.

Energy applications: the interest is in renewable energy devices that exploit nano-scale morphologies to increase efficiency. However, electrical effects are often strong enough to influence the structure of active layers of those materials leading to a notorious decrease in performance. To date, theoretical studies have dealt almost exclusively with uncoupled models of self-assembly and electrokinetics. We develop novel and computationally amenable mean-field frameworks that unify them. Our expectations are to advance devices, such as batteries, supercapacitors, and solar cells.

Biological applications: the interest is in self-organization that ranges from cellular to organ levels, such as spiral waves, pulses, synchronization, and steady states that are periodic in space. These non-equilibrium phenomena emerge through either spontaneous or forced symmetry-breaking mechanisms.

Qualifications
2008 → 2009 Postdoc, Technion
2006 → 2008 Postdoc, UCLA
2005 → 2006 Postdoc, UC Berkeley
2004 → 2005 Postdoc, Technion

Employment
Associate Professor
The Swiss Institute for Dryland Environmental and Energy Research
Ben-Gurion University of the Negev
1 Jul 2021 → present

Adjunct Associate Professor
Associate Professor
Department of Physics
Ben-Gurion University of the Negev
1 Jun 2022 → 30 Sep 2039

R&D Physicist
Landa Laboratories
Israel
1 Jan 2009 → 1 Jan 2012

Research outputs
Versatile Patterns in the Actin Cortex of Motile Cells: Self-Organized Pulses Can Coexist with Macropinocytic Ring-Shaped Waves

Parallel water photo-oxidation reaction pathways in hematite photoanodes: implications for solar fuel production

Origin of jumping oscillons in an excitable reaction-diffusion system

Stationary peaks in a multi-variable reaction-diffusion system: Foliated snaking due to subcritical Turing instability: Foliated snaking due to subcritical Turing instability

The nonlinear initiation of side-branching by activator-inhibitor-substrate (Turing) morphogenesis

Special issue: Advances in pattern formation

Assessing the impact of multiple comorbidities on fatal outcome in young COVID-19

Bending and pinching of three-phase stripes: From secondary instabilities to morphological deformations in organic photovoltaics

Spatial asymmetries of resonant oscillations in periodically forced heterogeneous media

Stripes on finite domains: Why the zigzag instability is only a partial story

Why a Large-Scale Mode Can Be Essential for Understanding Intracellular Actin Waves
Beta, C., Gov, N. S. & Yochelis, A., 23 Jun 2020, In: Cells. 9, 6

Excitable solitons: Annihilation, crossover, and nucleation of pulses in mass-conserving activator-inhibitor media

Spatial heterogeneity may form an inverse camel shaped Arnol'd tongue in parametrically forced oscillations

Controlling the interfacial and bulk concentrations of spontaneously charged colloids in non-polar media

Dynamical aspects of mean field theories for electrolytes and applications

Pattern formation aspects of electrically charged tri-stable media with implications to bulk heterojunction in organic photovoltaics
Two-site H$_2$O$_2$ photo-oxidation on haematite photoanodes

Electrochemically induced phase separation and in situ formation of mesoporous structures in ionic liquid mixtures
Lahiri, A., Behrens, N., Pulletikurthi, G., Yochelis, A., Kroke, E., Cui, T. & Endres, F., 26 Oct 2018, In: Science advances. 4 , 10, eaau9663.

Molding the asymmetry of localized frequency-locking waves by a generalized forcing and implications to the inner ear

Catalytic Membrane Reactor Model as a Laboratory for Pattern Emergence in Reaction-diffusion-advection Media

From solvent-free to dilute electrolytes: Essential components for a continuum theory

Fronts and waves of actin polymerization in a bistability-based mechanism of circular dorsal ruffles

From bulk self-assembly to electrical diffuse layer in a continuum approach for ionic liquids: The impact of anion and cation size asymmetry

Comb-like Turing patterns embedded in Hopf oscillations: Spatially localized states outside the 2:1 frequency locked region
Castillero, P. M. & Yochelis, A., 1 Apr 2017, In: Chaos. 27, 4, 043110.

Spatially localized self-assembly driven by electrically charged phase separation

Frequency locking in auditory hair cells: Distinguishing between additive and parametric forcing

Theory of Phase Separation and Polarization for Pure Ionic Liquids

Reaction-diffusion-advection approach to spatially localized treadmilling aggregates of molecular motors

Theory of phase separation and polarization for dissociated ionic liquids

Self-organization of waves and pulse trains by molecular motors in cellular protrusions

Coupling Bulk and Near-Electrode Interfacial Nanostructuring in Ionic Liquids
Origin of finite pulse trains: Homoclinic snaking in excitable media

Spatial structure of electrical diffuse layers in highly concentrated electrolytes: A modified poisson-nernst-planck approach

Transition from non-monotonic to monotonic electrical diffuse layers: Impact of confinement on ionic liquids

Linking actin networks and cell membrane via a reaction-diffusion-elastic description of nonlinear filopodia initiation

Why turing mechanism is an obstacle to stationary periodic patterns in bounded reaction-diffusion media with advection

Drifting solitary waves in a reaction-diffusion medium with differential advection

Principal bifurcations and symmetries in the emergence of reaction-diffusion-advection patterns on finite domains

Towards nonlinear selection of reaction-diffusion patterns in presence of advection: A spatial dynamics approach

Bifurcation and chaos in a model of cardiac early afterdepolarizations

Classification of spatially localized oscillations in periodically forced dissipative systems

Generation of finite wave trains in excitable media

The formation of labyrinths, spots and stripe patterns in a biochemical approach to cardiovascular calcification

Front motion and localized states in an asymmetric bistable activator-inhibitor system with saturation

Matrix GLA protein, an inhibitory morphogen in pulmonary vascular development

Formation and mobility of droplets on composite layered substrates

Reciprocal oscillons and nonmonotonic fronts in forced nonequilibrium systems
Linear and nonlinear front instabilities in bistable systems

Thin films of van der Waals fluid: From interface interactions to wetting transitions

Droplet motion driven by surface freezing or melting: A mesoscopic hydrodynamic approach

Frequency locking in extended systems: The impact of a Turing mode

Two-phase resonant patterns in forced oscillatory systems: Boundaries, mechanisms and forms

Development of standing-wave labyrinthine patterns

Oscillon formation as an initial pattern state

Nuclear spin-lattice relaxation of dipolar order caused by paramagnetic impurities