



TECHNION
Physics
Department

Technion Physics Faculty Research 2024



The Technion Physics Department Is home to those who seek to uncover the inner workings of the Universe, from tiny subatomic particles to the cosmic horizon at 10 billion light years. We study aspects of the broadest range of human knowledge: Quantum Sciences, Einstein's theory of Relativity, Atoms and Molecules, Astrophysics and Cosmology, Complexity of biological and Ecological Systems, Condensed Matter, High Energy Physics and Plasma Physics.

The Technion Physics undergraduate and graduate programs are diverse and adaptive, with the goal of empowering and inspiring the next generation of original thinkers in science and innovative technology. A creative and dynamic approach, aided by top-notch research and teaching infrastructures, enables us to forge a strong bond between research and education, both at the highest level.

The department advances strong international ties and hosts numerous international conferences via the Lewiner Institute for Theoretical Physics. As part of Israel's top Technology Institute, the department maintains joint initiatives with fellow Technion engineering departments. We are also associated with several research institutes at the Technion, including the Asher Space Research Institute (ASRI), Helen Diller Quantum Center, Russell Berrie Nanotechnological Institute and the Solid State Institute.

Professor Adi Nusser

Dean of the Technion Physics Department

List of faculty members by research fields

Astrophysics, cosmology and general relativity

[Behar Ehud](#)

[Bialy Shmuel](#)

[Desjacques Vincent](#)

[Laor Ari](#)

[Nusser Adi](#)

[Ori Amos](#)

[Perets Hagai](#)

[Soker Noam](#)

Complex Systems

[Bunin Guy](#)

[Frishman Anna](#)

[Kafri Yariv](#)

[Levine Dov](#)

[Svetlizky Ilya](#)

High Energy Physics

[Bergman Oren](#)

[Blok Boris](#)

[Kajomovitz Enrique](#)

[Razamat Shlomo](#)

[Rozen Yoram](#)

[Shadmi Yael](#)

[Soreq Yotam](#)

[Tarem Shlomit](#)

[Yarom Amos](#)

Atomic and Molecular Physics

[Krueger Michael](#)

[Ohayon Ben](#)

[Sagi Yoav](#)

[Steinhauer Jeff](#)

Condensed Matter Physics

[Akkermans Eric](#)

[Auerbach Assa](#)

[Hacohen-Gourgy Shay](#)

[Kanigel Amit](#)

[Keren Amit](#)

[Keselman Anna](#)

[Lindner Netanel](#)

[Podolsky Daniel](#)

[Reznikov Michael](#)

[Turner Ari](#)

Non-linear Optics

[Cohen Oren](#)

[Segev Moti](#)

Biophysics

[Adar Ram](#)

[Braun Erez](#)

[Keren Kinneret](#)

[Sivan Uri](#)

Plasma Physics

[Krasik Yakov](#)

Quantum Science and Technology

[Arad Itai](#)

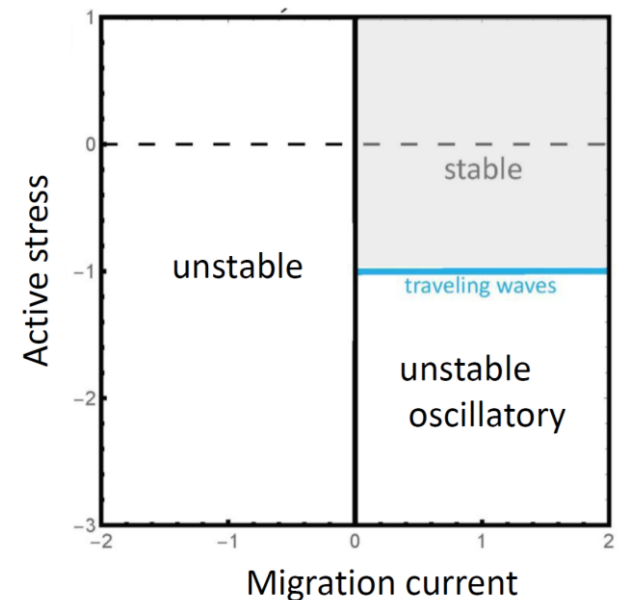
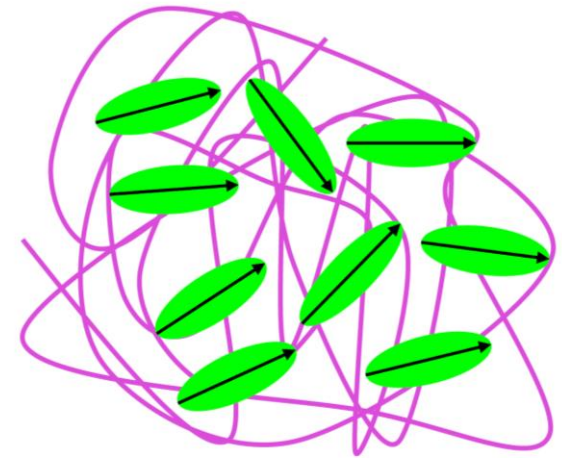
Ram Adar

Biophysics and Soft Active Matter

My research interests lie at the crossroads of biological physics, soft active matter, and statistical mechanics. I am motivated by experimental observations and use theoretical analysis and computational tools to understand them. My general goal is to discover new physical effects in biological systems and to explain biological processes from a physical perspective.

The central theme of the group's research is the feedback between cells and their environment from the single cell to tissue level. For example, we ask how do migrating cells create patterns in their surrounding tissue and how do these patterns promote further migration? We tackle this question by modeling the cells together with their environment as an active gel. Answering this question will help to better understand key biological processes such as metastasis, in hopes of promoting human health.

Cells in tissue as an active gel



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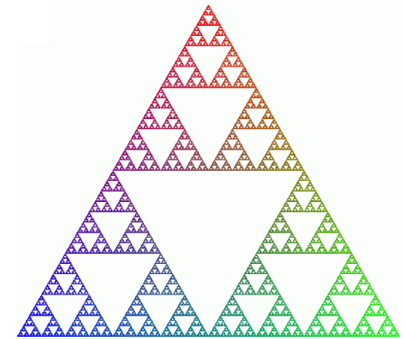
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Eric Akkermans

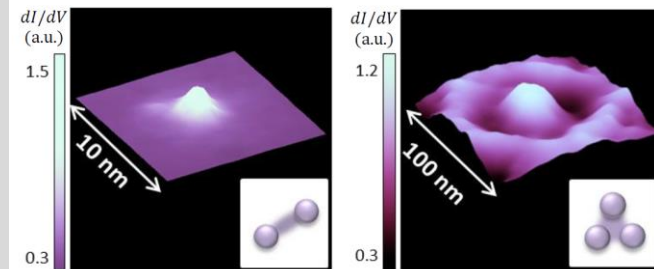
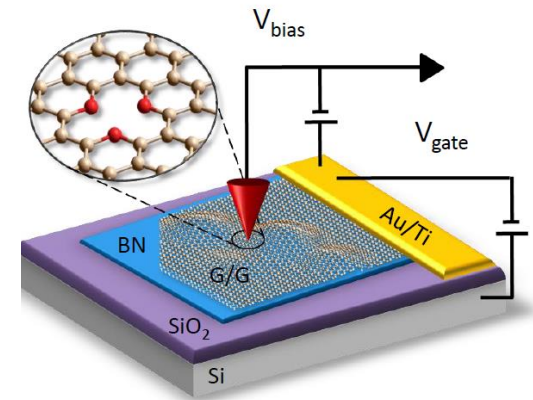
Theoretical Condensed Matter Physics

Condensed matter sits at the crossroad between several fields of Physics, such as quantum physics, equilibrium and far from equilibrium statistical physics, quantum field theory, cold atomic gases and mesoscopic physics. We enjoy working in each of these fields trying to find overlaps and to use new theoretical tools and inspiration to relate them.

While being theoreticians, in our group we put special emphasis working in collaboration with experimental groups worldwide.



$$\rho(\lambda E) = \lambda^{-1} \rho(E)$$



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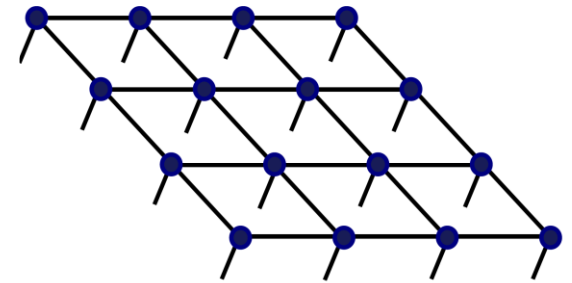
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Quantum Information

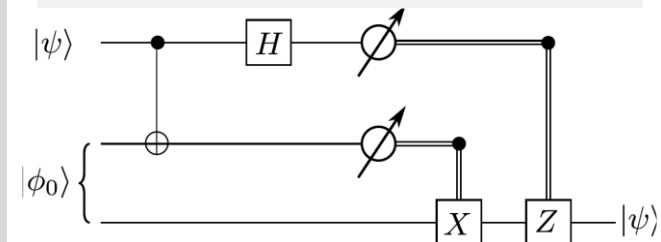
Quantum information is an interdisciplinary research field, combining quantum mechanics, computer science, condensed matter physics and statistical physics with beautiful math. It is an exciting field that enjoys a constant flux of ideas from theory and experiments. In recent years, with rise of quantum computers, it is also becoming central for many types of industries.

Quantum Hamiltonian complexity is a sub-field of quantum information, in which we try to understand many-body systems using insights and techniques from computer science and information theory. This include, for example, questions like what is the computational complexity of simulating many-body quantum systems? When can these systems be represented efficiently by tensor-networks? How does entanglement scale in these systems? Can we learn these systems using only local measurements? Can we characterize the noise in a quantum computer, or verify a quantum computation, even though we cannot fully simulate it on a classical computer?

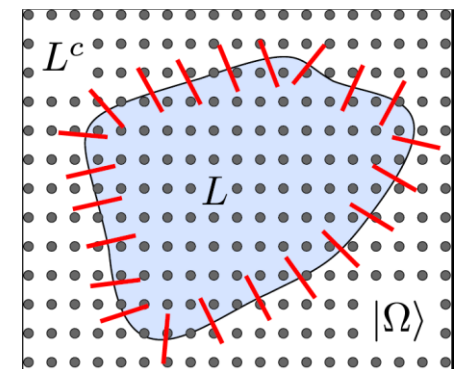
Tensor Networks



Teleportation



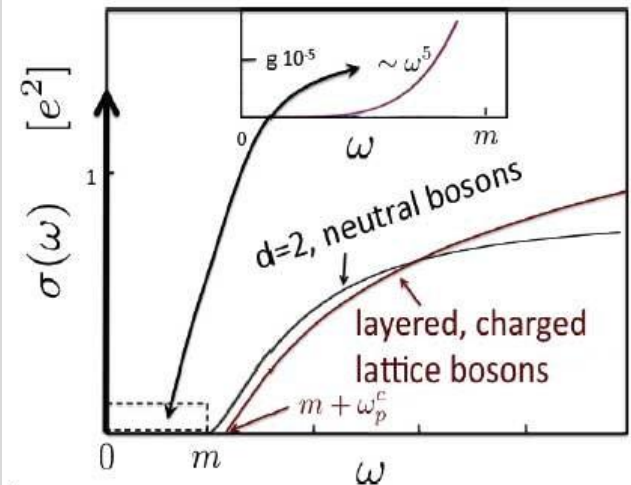
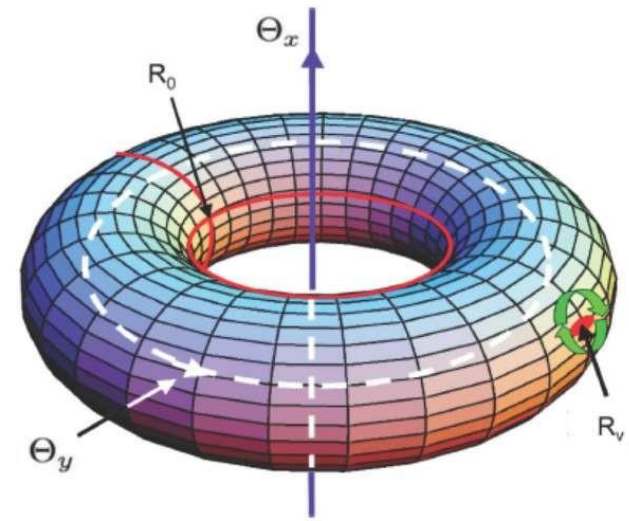
Area Laws



Strongly Correlated Electrons and Quantum Phases of Matter

Theoretical studies of condensed matter systems which exhibit interesting quantum phases at low temperatures. These include superconductivity, superfluidity strange metals, quantum solids, spin liquids, heavy fermions, and quantum Hall phases.

My work has concentrated on outstanding puzzles, anomalies and unexpected behavior in these systems, which contradict many expectations of traditional approaches. On the way new formulas and many theoretical techniques have been developed and are ready to be applied.



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Experimental High Energy Astrophysics

Our research program has an instrumental leg and an observational one. My group develops γ -ray detectors for space with the goal of finding and understanding the electromagnetic counterparts of neutron star binary mergers. We also use the most modern instruments in space and on the ground, from γ -rays to radio observations, as well as theoretical models, to research high-energy astrophysical phenomena.

We research targets such as black holes, coronally active stars, galactic and stellar winds, and gamma ray bursts, as well as the elusive intergalactic medium. My main interests are to detect and characterize plasma under extreme conditions, e.g., just before it falls into a black hole, when it is launched to sub-luminal speeds, or when it is shock heated to millions of degrees.

Some fundamental questions we are interested in are: What is the electromagnetic signal of gas near a black hole? How are black-hole winds launched? Where are the missing atoms of the Universe? What is the connection between the magnetic corona of stars, and that of black-hole accretion disks.



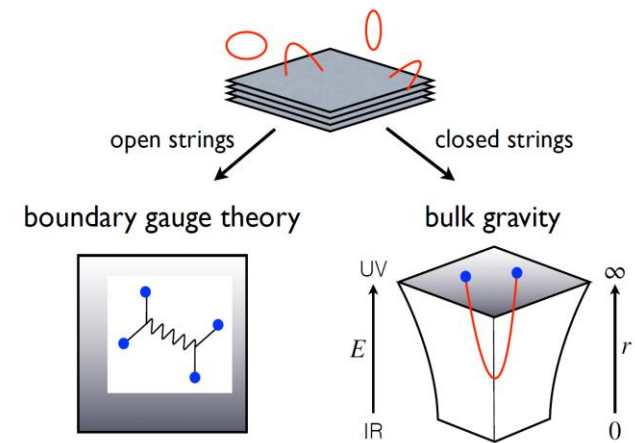
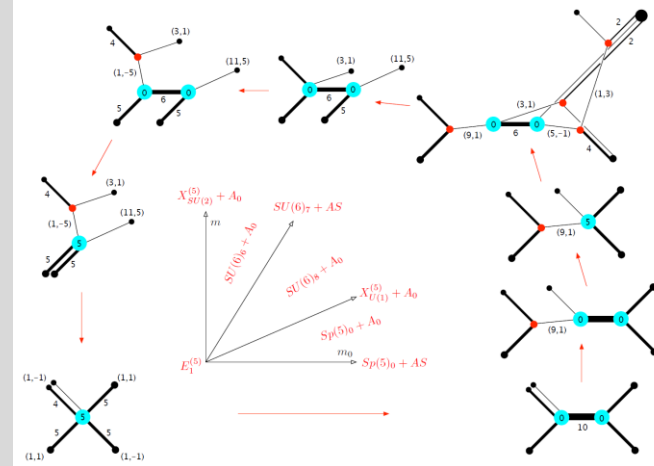
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String Theory and Quantum Field Theory

Quantum field theory (QFT) is the general framework used to describe many body quantum systems. Although it has been around for seventy years, and has allowed us to predict numerous results in diverse fields such as high energy physics, condensed matter physics, and cosmology, we are still learning many new things about QFT today. My current research is focussed on extracting interesting lessons about QFT from string theory. String theory, as we understand it today, provides a new framework for QFT, allowing us to define and study QFT's beyond the traditional approaches of Lagrangians and perturbation theory.

I am particularly interested in higher-dimensional QFT's, which are notoriously difficult to analyze using the traditional tools. String theory provides new tools which allow us to define and characterize these theories. One of the main goals of this program is to classify all five and six-dimensional QFT's. This will also be relevant for the more physical QFT's in four and three spacetime dimensions, since these are related to the higher-dimensional theories via compactification.



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Shmuel Bialy

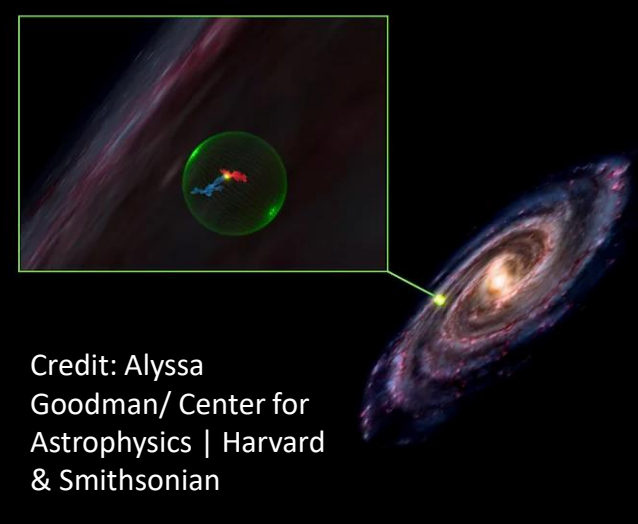
analytic and numerical modeling of physical processes in the interstellar medium (ISM)

Research Interests & Publications:

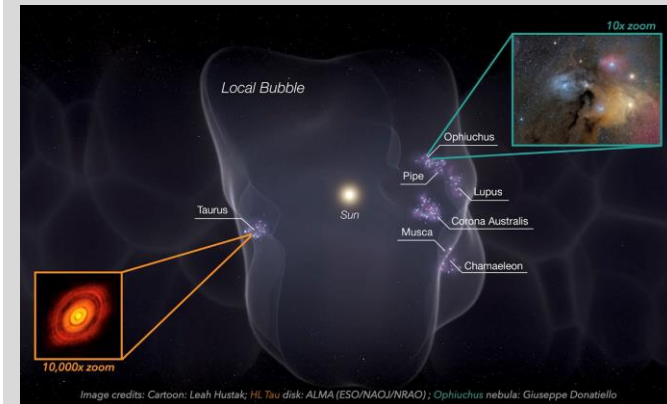
Star-Formation, Cosmic-Rays, Turbulence, Galaxy Evolution, The Interstellar-Medium, Astrochemistry, Data Visualization

I specialize in analytic and numerical modeling of physical processes in the interstellar medium (ISM). My goal is to obtain a deep understanding of how star formation operates in galaxies, and how the forming stars shape the ISM and regulate the evolution of galaxies across cosmic times.

Our group combines multi-physics magneto-hydrodynamics simulations with analytic theory to study the process of star-formation and galaxy evolution. We collaborate with observers to compare theory with observations in galaxies today and in high redshift galaxies forming in the Early Universe. An interesting aspect of our research is that it is inter-disciplinary, involving knowledge from different fields: chemistry, turbulence, hydrodynamics, atomic physics, and cosmology.



Credit: Alyssa Goodman/ Center for Astrophysics | Harvard & Smithsonian



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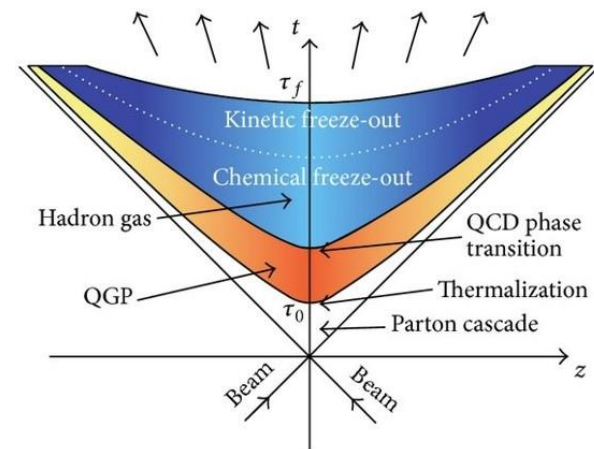
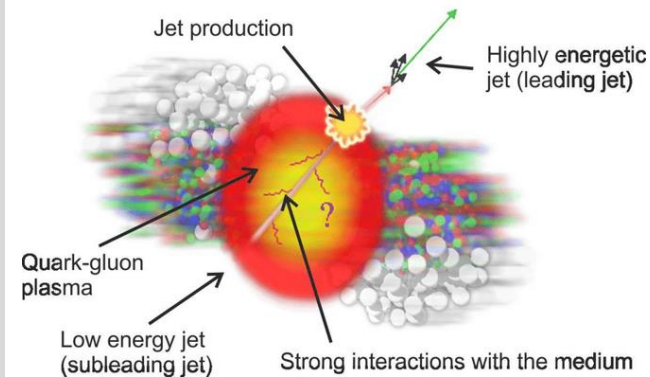
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Theoretical High Energy Particle and Nuclear Physics

My research concerns the theory of strong interactions- Quantum Chromodynamics (QCD). This is the theory of quarks interacting by means of gauge fields -gluons. In particular I am interested in applications of QCD to novel physical phenomena observed at Large Hadron Collider (LHC) in CERN in Geneva.

1. Heavy ion (i.e. nucleus-nucleus) collisions and their dynamics, creation and diagnostics of new state of matter - Quark Gluon Plasma (QGP). This research involves the use of perturbative and nonperturbative QCD, relativistic statistical mechanics and relativistic kinetic theory.
2. Application of perturbative QCD (i.e. described by Feynman diagrams) to the search of new particles beyond the standard model and to the precise determination of the parameters of the standard model.
3. Theory of confinement, how one can see confinement effects at high energy processes at LHC?

The research is in close collaboration with theory groups in CERN and Penn.



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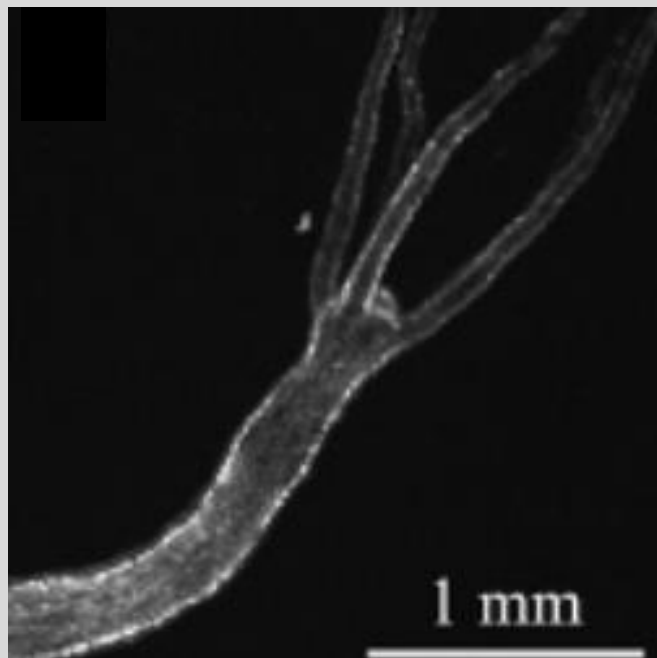
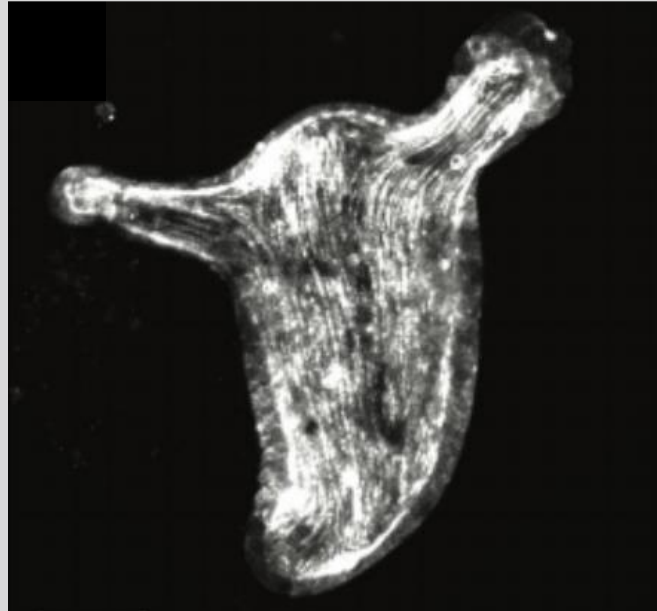
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Erez Braun

Biophysics

My research is in the area of experimental biophysics and is tightly connected to other areas in physics such as non-linear dynamics, pattern formation, soft condensed-matter and statistical mechanics. In recent years, our research was focused on the physics of morphogenesis—the emergence of a body plan in animal development. This is a fascinating open front in the physics of complex systems.

Our research concentrates on physical mechanisms underlying this remarkable self-organization dynamics; mechanical (in collaboration with Prof. Kinneret Keren) and electrical processes. The main experiments utilize external fields to perturb and direct morphogenesis in Hydra; magnetic fields to apply mechanical perturbations and electric fields to stimulate electrical modulations.



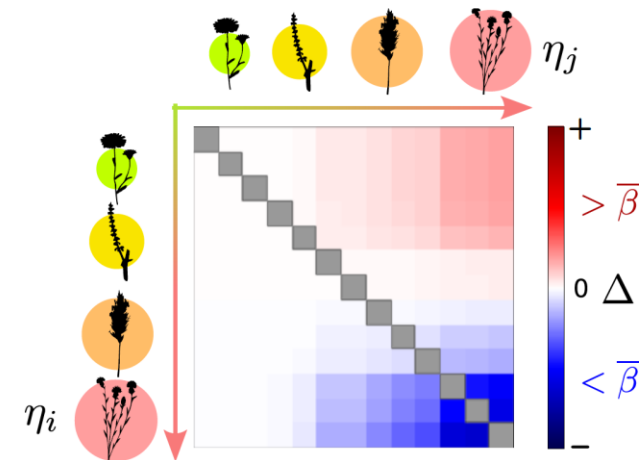
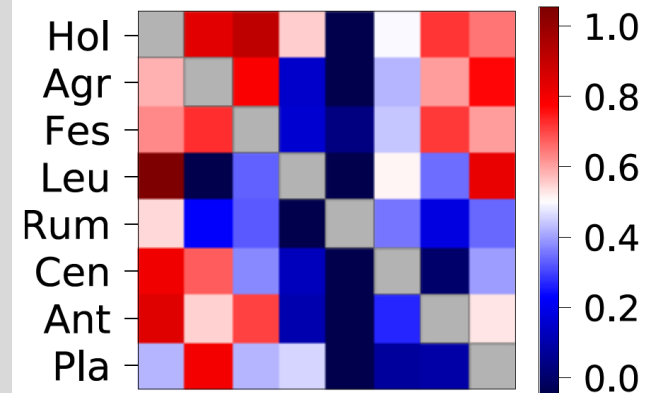
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Guy Bunin

Theory of Interacting Systems' Dynamics

Recently, much of the work is on dynamics of ecosystems. The focus is on “high-dimensional” dynamics, that are described by many variables, such as many coexisting species.



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Oren Cohen



High Laser-field Physics

Ultrafast optics & Attosecond Science

Ultrahigh-speed & Super-resolution Imaging

We develop sources of extreme ultraviolet pulses with femtosecond to attosecond duration (femto and atto correspond to 10^{-15} and 10^{-18} , respectively) and with fully controllable polarization. We employ these unique sources for exploring ultrafast dynamics in magnetism, chirality, and of charge and spin currents in atoms, molecules and solids.

We develop a microscope for exploring ultrafast phase transitions (e.g. femto-magnetism) with nanometer and picosecond resolution scales.



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Vincent Desjacques

Theoretical Cosmology

I am interested in the formation and evolution of structures in the Universe. I develop physical models and statistical methods in order to properly interpret observational data and extract information on the nature of dark matter, dark energy, the law of gravity and the initial conditions of the Universe. I am working on perturbation theory approaches to the large scale structure. I am also exploring ways to constrain the properties of dark matter with cosmological and astrophysical probes.

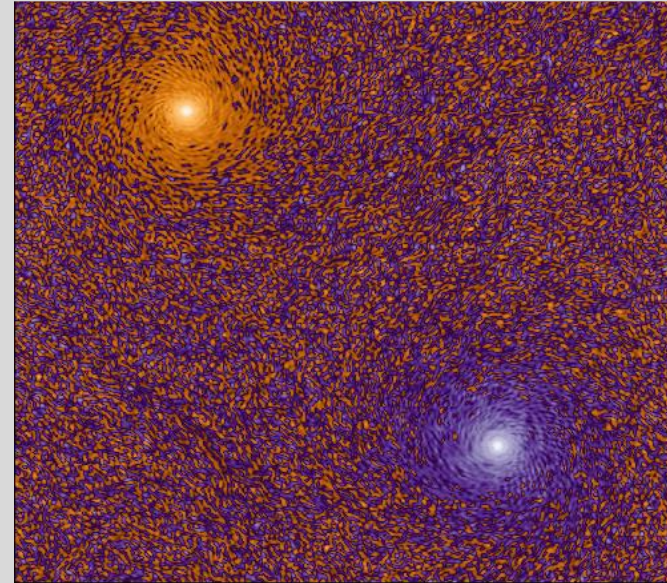


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Statistical Physics and Fluid Mechanics

I am interested in fundamental aspects of out-of-equilibrium systems and fundamental problems in fluid mechanics, with turbulence lying at the intersection.

I aim to directly connect theoretical concepts and understanding with real-world phenomena. Recent and current projects include: the inference of equations of motion and entropy production from stochastic trajectories, and the connection to information theory; developing a statistical theory for turbulent flows with a coherent component, such as the flow in a pipe or the jet stream in the atmosphere; modeling of the statistics of water droplets in clouds with an emphasis on implications to macroscopic properties of the cloud.

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Shay Hacoen-Gourgy

SQC-lab. Circuit-QED – Quantum information and quantum optics using superconducting circuits

Light-matter interaction is the underlying mechanism for measurement and control in quantum mechanics. We use superconducting circuits to realize quantum devices, where microwave photons are used for measurement, control and interaction, in a framework known as circuit-QED. Our research is at the intersection of atomic physics, condensed matter physics and quantum optics. Design and fabrication of circuits allows us to realize physical systems where the light-matter interactions are stronger than in natural systems, resulting in new phenomena and a deeper understanding of physics.

We study a range of topics from quantum computing and quantum simulations to fundamental physics. We focus on hardware improvement, problems of robust quantum control, and novel methods for encoding quantum simulations. We utilize our platform's exquisite control and precision measurement capabilities to gain a better understanding of quantum measurements and open quantum systems. Since interaction with the environment is inevitable it is important to find control methods that are robust to the effects of the environment, or better harness this interaction to achieve control.



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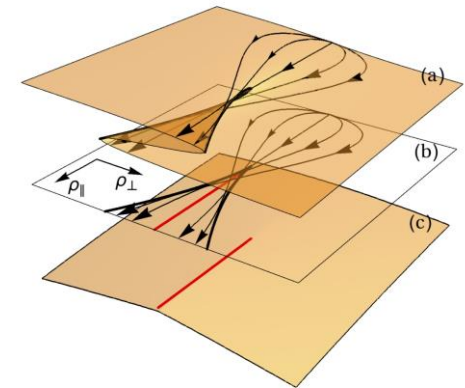
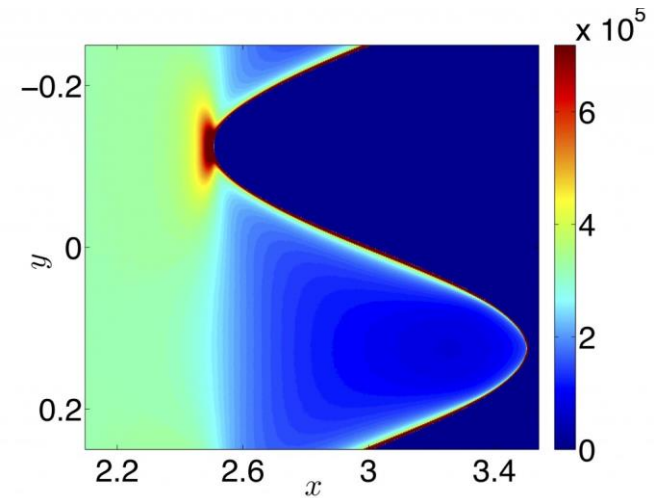
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Statistical Physics

My group is focused on understanding theoretically far from equilibrium systems. In particular, in recent years we have studied a class of non-equilibrium systems which are termed active systems. They consist of a collection of *self-propelled* particles and their study has applications in systems ranging from biological through artificial. Moreover, they hold promise as a pathway to the design of novel self-assembling materials. They display a host of novel phenomena. For example, phase separation in the absence of attractive interactions between the particles. Of particular interest to us were the forces exerted by these systems which many times defy our equilibrium-based intuition.



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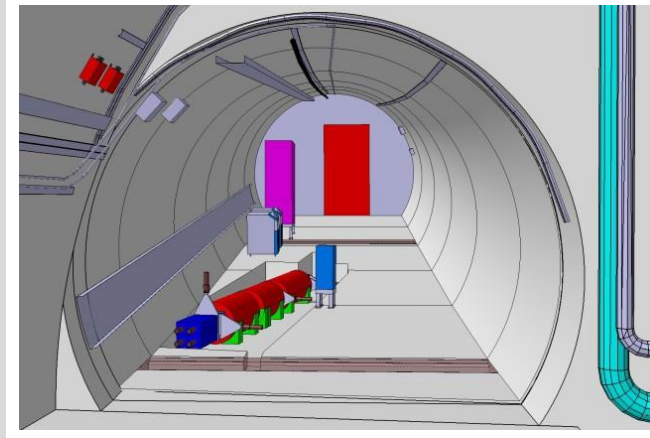
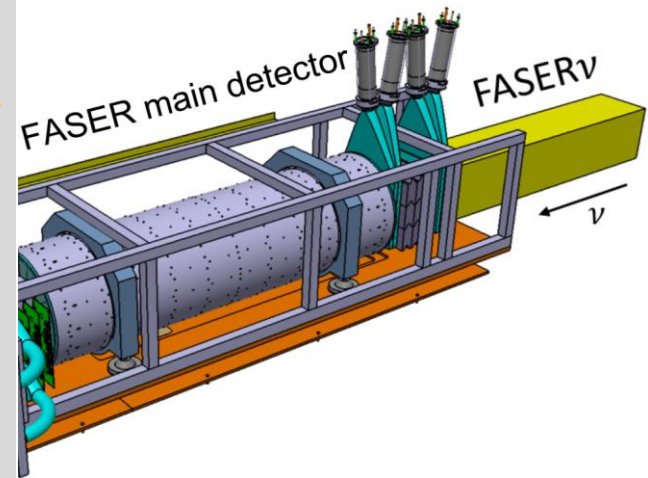
Enrique Kajomovitz

Experimental High Energy Physics

The scientific goal of my group is the discovery of physics beyond the standard model (BSM). We are part of the ATLAS and FASER experiments at CERN, where we are searching for evidence of Physics Beyond the Standard Model.

In ATLAS my group uses hadronic signatures to search for new particles with masses ranging from tens of GeVs to a few TeVs. We also use unconventional signatures to search for new forces that would only interact with muons. In the FASER experiment we are searching for new very light and long-lived states that could be produced at the LHC collisions and decay to a pair of electrons hundreds of meters from the point where they are produced.

My group is also very active in the development of new instrumentation. In ATLAS we are part of the New Small Wheel upgrade, in FASER we are part of the Trigger and Data Acquisition systems. We also work in the R&D for experiments beyond the LHC.



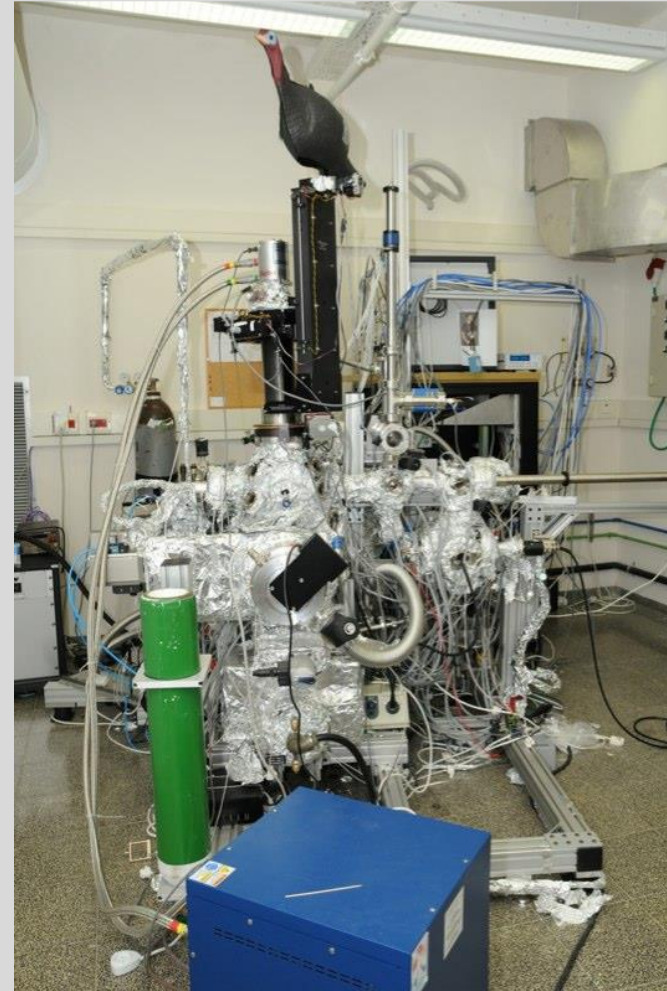
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Strongly Correlated Materials

In our lab we prepare crystals of strongly correlated materials such as: superconductors, exotic magnets and topological insulators, using different methods. Our goal is to understand the physics of these systems by measuring very precisely their electronic structure. Our main tool is Angle Resolved Photoemission Spectroscopy (ARPES) a neat technique that allows one to measure the dispersion of electrons in a crystal. We have a state-of-art ARPES setup in the lab and we also travel for ARPES experiments to various synchrotrons in Europe.



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Superconductivity

In recent years we developed a new method to characterize the major properties of superconductors in unprecedented sensitivity. This allows us to characterize new and exotic superconductors. Now we are aiming to miniaturize our instrument to the nano scale and attach our instrument to a scanner. This will allow us to detect superconductivity in artificial nano structures and study their properties.



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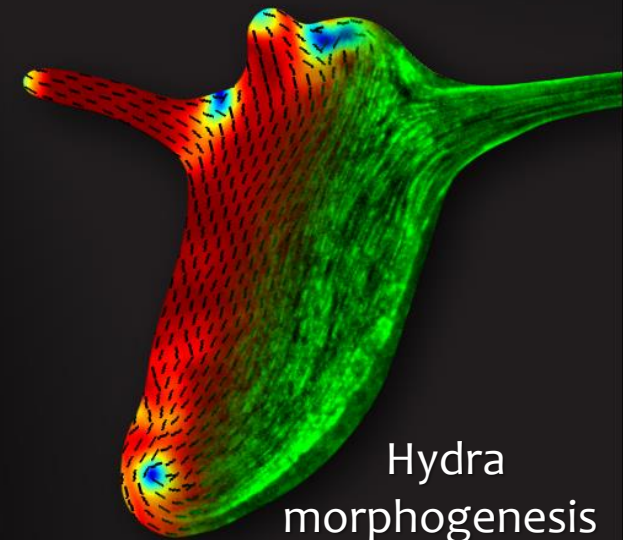
Kinneret Keren

Biophysics (experimental)

My research lies at the interface of physics and biology. I am interested in biophysical aspects of self-organization and pattern formation in biological systems. Research in my lab is currently centered along two main directions. First, at the cellular level, we study fundamental aspects of cell mechanics and movement in natural and engineered systems. We are developing artificial cells in which we reconstitute dynamic cytoskeletal networks and study their behavior in a controlled environment. Second, at the multicellular level, we are exploring the emergence of patterns and the formation of the body plan during animal development (in collaboration with Prof. Erez Braun). Specifically, we utilize the small predatory animal, Hydra, famous for its extraordinary regeneration capabilities, to study the role of mechanical processes and feedback in the development of functional form in multicellular animals.



Artificial cells



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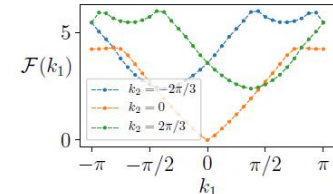
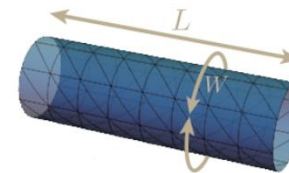
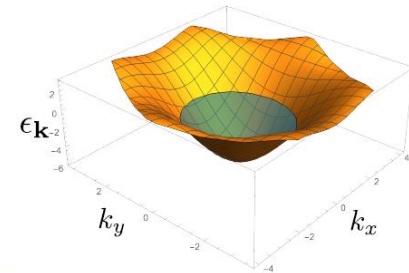
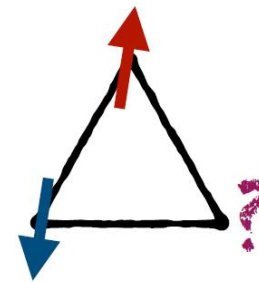
Anna Keselman

Condensed matter (theory)

Numerical many-body methods

My research focuses on quantum many-body systems. In such systems interactions between many particles give rise to novel emergent phenomena in which quantum entanglement plays a crucial role. In particular I am interested in frustrated quantum magnets and topological phases in electronic systems. I like studying microscopic models relevant for real materials and thinking about signatures for the appearance of novel phases of matter in experiments.

In my studies I employ state of the art numerical techniques appropriate for the study of strongly correlated systems such as the density matrix renormalization group (DMRG) and related tensor network methods.



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Yakov Krasik

Research of Extreme States of Matter produced by Underwater Electrical Wire Explosions.

Research of Generation and Convergence of Strong Shock Waves.

Research of high-power Microwave Interaction with Plasma and Wake-Field Formation.

- Phase transitions (solid state-liquid-vapor – low-ionized non-ideal plasma) experienced by wire subjected by extremely high energy density deposition > 100 eV/atom
- Overheating instabilities of exploding wires leading to striation formation
- Symmetry of converging cylindrical and quasi-spherical shock waves and formation of extreme state of water with Mbar pressure in the vicinity of the shock implosion
- Self-guiding of high power microwave beam and its propagation without divergence; wake-field formation and super-energetic electrons generation during microwave pulse interaction with neutral gas and preliminary formed plasma



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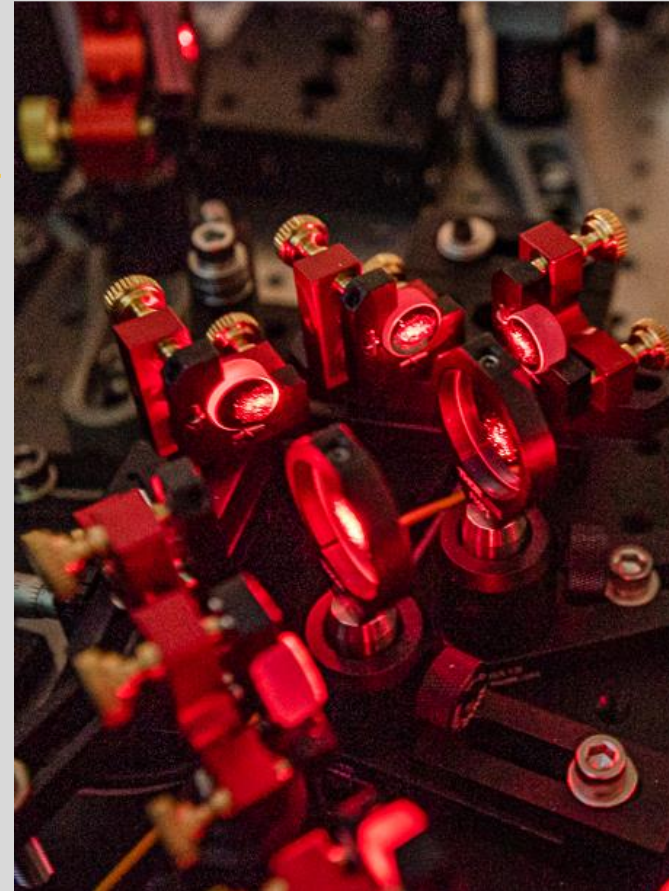
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Attosecond Spectroscopy on the Nano-scale, Ultrafast Plasmonics and Nonlinear Optics

In our lab we investigate ultrafast electron dynamics in space and time. Our research aims at studying coherent many-body quantum phenomena, predicted for finite-size systems, such as molecules and nanowires. However, in many cases decoherence destroys the experimental signatures of these phenomena very quickly after their creation.

In order to observe this new physics, we are pushing the limits of both spatial and temporal measurements to their absolute extremes, the attosecond (10^{-18} s) and angstrom (10^{-10} m) scales. To this end we will integrate standard imaging methods, such as scanning probe microscopy, with ultrafast spectroscopy. Our research will show to what extent multi-electron dynamics can be predicted, observed and controlled.



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Physical Processes Near Massive Black Holes

- Matter, radiation, and their interaction near massive black holes in Active Galactic Nuclei
- Theoretical and observational work on the radio and the X-ray emission
- The physical mechanism underlying their relation
- The overall spectral energy distribution, and its relation to the black hole mass, luminosity, and gas metallicity
- Particle dynamics and collisional viscosity in an accretion disk
- The formation of power-law distributions in various systems



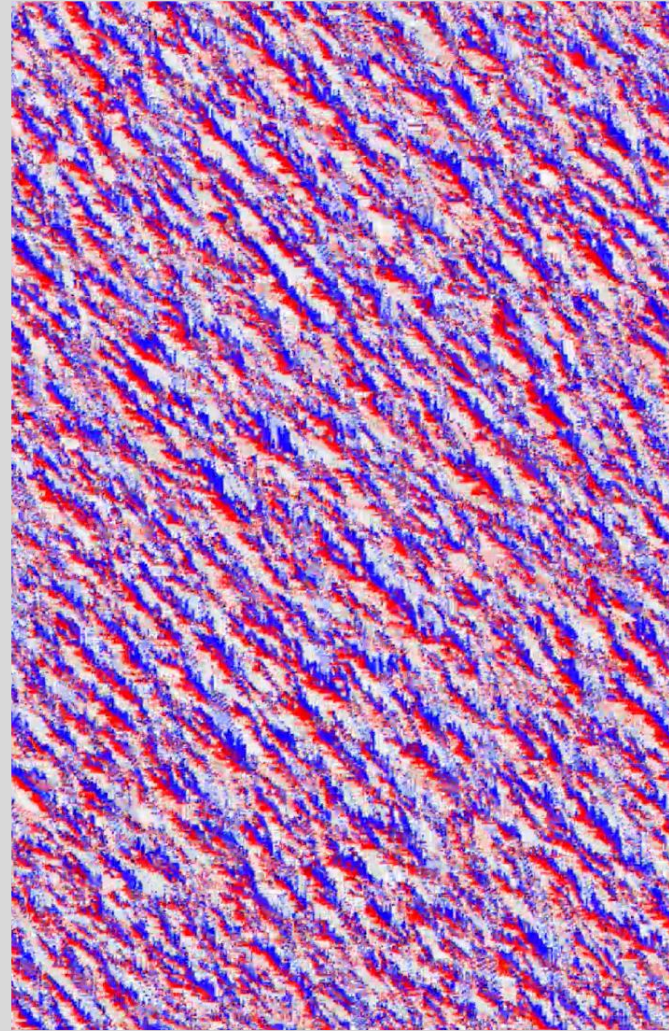
[NASA](#), [ESA](#), S. Bianchi (Università degli Studi Roma Tre University), A. Laor (Technion-Israel Institute of Technology), and M. Chiaberge ([ESA](#), [STScI](#), and [JHU](#))

Statistical Mechanics, Soft Matter Physics

My research centers on phenomena exhibited by classical many-body systems, in particular when they are far from equilibrium.

Out of equilibrium systems often show correlations and phase transitions which are very different from their equilibrium analogs.

I am particularly interested in the nature of ordering, both static and dynamic, which arises in these contexts, which forces us to examine anew our fundamental assumptions of what order means. This reexamination leads us to the study of exotic ordered systems as well as cooperative complex systems which show fascinating self-organization and dynamic phase transitions.

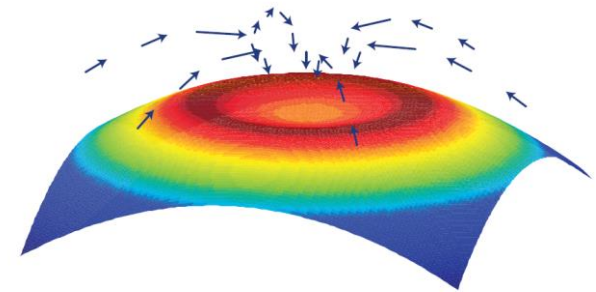
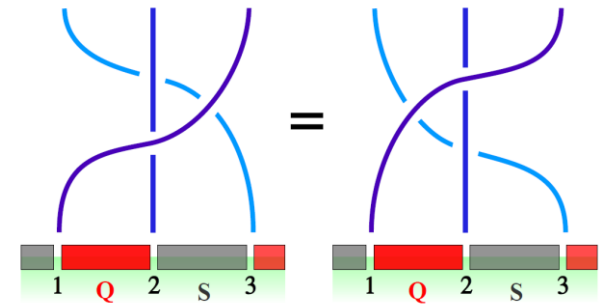


Netanel Lindner

Condensed Matter Physics, Physics of Quantum Computing

My research centers on quantum phases in condensed matter systems, and in particular, on topological phases of matter. These are quantum phases of matter which cannot be classified using the notion of spontaneous symmetry breaking. Instead, studying them requires the use of tools borrowed from the mathematical field of topology.

I deal with questions such as: what types of topological phases exist, how can they be realized in the lab, and what can they be good for? In particular, I study how to use topological phases as platforms for performing quantum information and computation tasks. Concurrently, I'm pursuing methods to induce and detect new types of topological phases in externally driven systems, for example, by utilizing light-matter interactions. Such systems are out of thermodynamic equilibrium, yielding rich physics and unique topological phases of matter.



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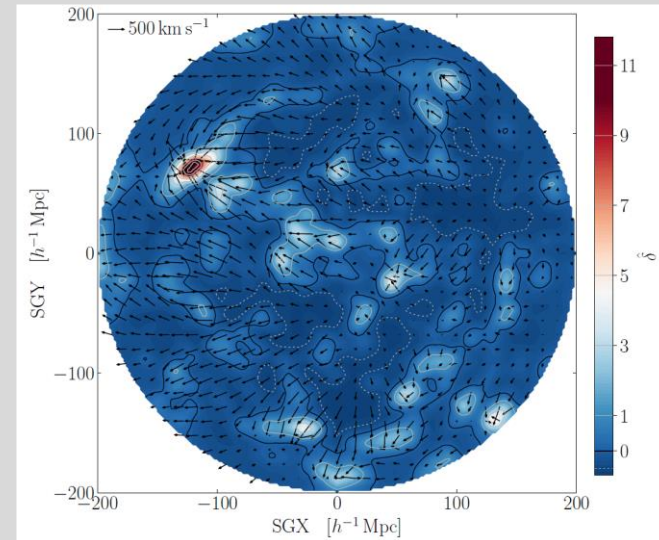
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Cosmology and the Formation of structure in the Universe

Galaxies are arranged in a Cosmic Web of clusters, filaments and “pancake”.

In the highly successful standard cosmological model, this Cosmic Web has formed via gravitational amplification of tiny mass fluctuations formed near the Big Bang singularity.

Most of the matter in this Web is dark of yet unknown nature. Adi Nusser’s research focuses on the interplay between the expanding cosmological background and the process of structure formation. He has special interest in probing fundamental physics through cosmological observations.

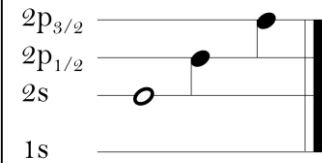


Exotic atoms and nuclei

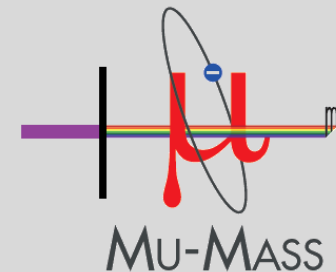
Our group focuses on precision measurements in exotic atoms - bound systems in which one or more of the constituents in an exotic particle (muon, antiproton, ...). Compared with ordinary systems such as the hydrogen atom, exotic atoms allow to amplify or even turn-off certain properties of the atom. For example increasing the electric fields by orders of magnitude or removing finite-size effects.

We are currently focused on Muonium - the simplest atom; Muonic atoms - the ideal systems to study nuclear structure; and antihydrogen - the only antimatter system amenable to spectroscopy. Our research thus lies in the intersection of atomic, particle and nuclear physics.

QUARTET



Applying quantum sensing to **muonic atoms** for nuclear structure & tests of QED in extreme fields



Testing Quantum Electrodynamics with **muonium** – the simplest atom



Spectroscopy and gravity tests with **antihydrogen**

General Relativity

Over the last ~10 years I have primarily been working on several open problems in the theory of black holes (BHs): What happens deep inside BHs? How does the evaporation of the BH affect its internal structure? What is the final fate of the BH, when it completes its evaporation? We try to address these and similar questions, using the classical theory of General Relativity combined with the semiclassical theory of gravity.

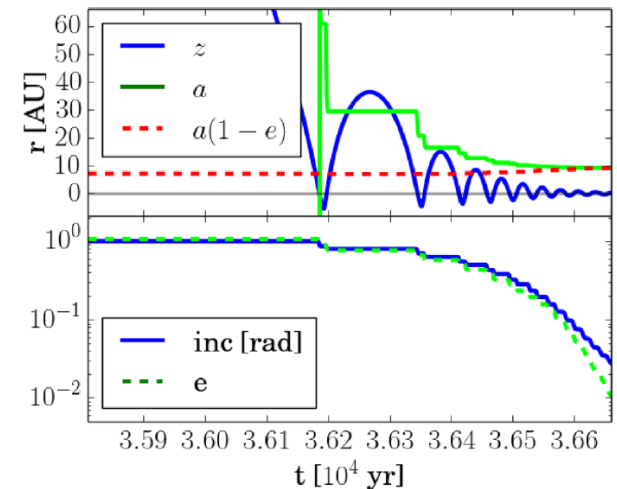
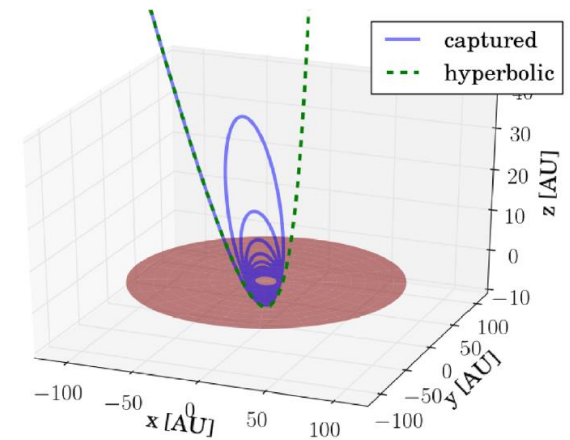


Astrophysics and Planetary Science

My main work deals with stellar and planetary dynamics. I study planet formation and try to understand the origin and evolution of the Solar system and of exoplanet systems, including the origin of moons (Earth Moon and gas-giant moons). I also explore the evolution of multiple systems (triple stellar systems, and multi-planet systems) through dynamical and secular interactions and their coupling to stellar evolutionary processes.

I study the collisional dynamics of stars in dense systems such as globular clusters and clusters around massive black holes and the strong interactions of stars with black holes, including the tidal disruption of stars, gravitational wave sources capture of stars close to the massive black hole in the Galactic center and ejection of hypervelocity stars.

Finally, I also study a wide range of thermonuclear supernovae explosions and the origin of non-standard supernovae through hydrodynamical simulations as well as analysis of observational data.



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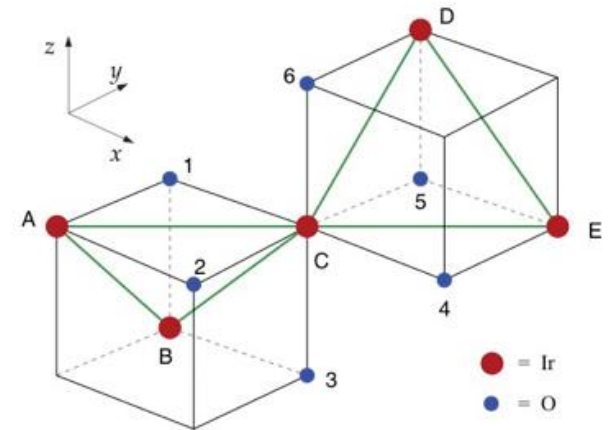
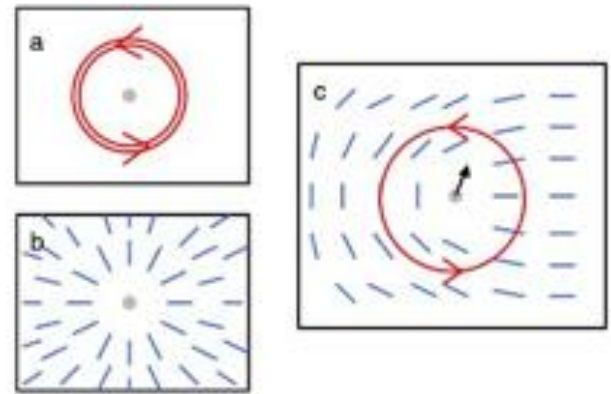
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Daniel Podolsky

Theoretical Condensed Matter Physics, Strongly Correlated Systems

Quantum systems of particles with strong interactions give rise to many fascinating phenomena, including high temperature superconductivity, fractional Quantum Hall states, and quantum spin liquids, among others. My group does theoretical research on such systems, with an emphasis on explaining open experimental puzzles. Our interests include topics as varied as the study of dynamics near quantum critical points, the steady-state properties of driven many-body systems, and the optical properties of out-of-equilibrium superconductors.



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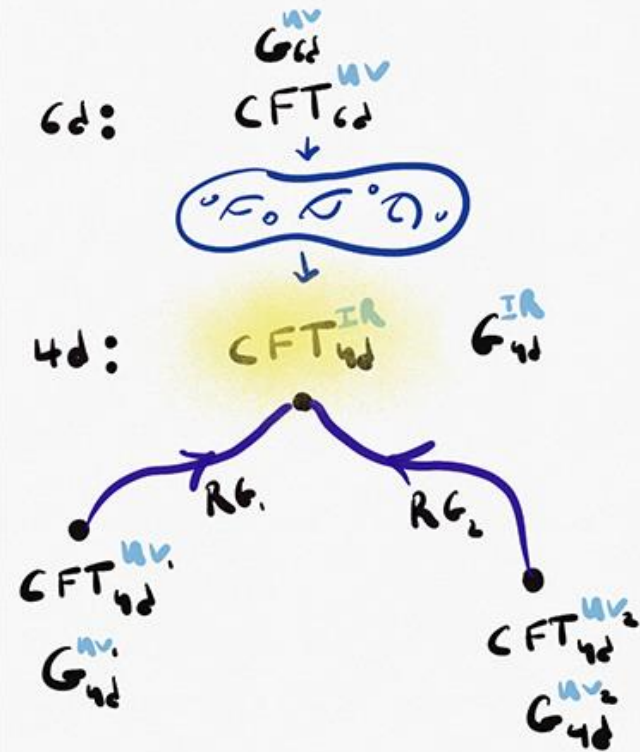
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Shlomo Razamat

Quantum Field Theory, String Theory,
Mathematical Physics

Quantum field theory is one of the most successful tools we possess to describe and Quantify physical phenomena. The scope of its application is vast and ranges from the standard model of elementary particles to effective theories describing condensed matter systems. Yet, beyond certain simplifying regimes, due to the intrinsic complexity of quantum field theories extracting explicit and exact physical information from these models is a notoriously hard problem.

My main research interests are revolving around developing better understandings of the nuts and bolts of a general quantum field theory.



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Michael Reznikov

Mesoscopic Physics Lab

Short Noise measurements of the carrier's charge in High Temperature (HTC) Superconductors. Current research projects:

- Vortex charge measurements in HTC superconductors. Besides being interesting on its own, the charge is predicted to affect the Hall conductivity, therefore its measurements can help to solve a long-standing puzzle of the Hall effect anomaly in HTC.
- Electron temperature measurements in hydrodynamic regime in Graphene. Unusual heat transfer in Graphene, due Dirac electron spectrum, leads to large heat-induced voltage, and therefore to potential applications in energy harvesting.



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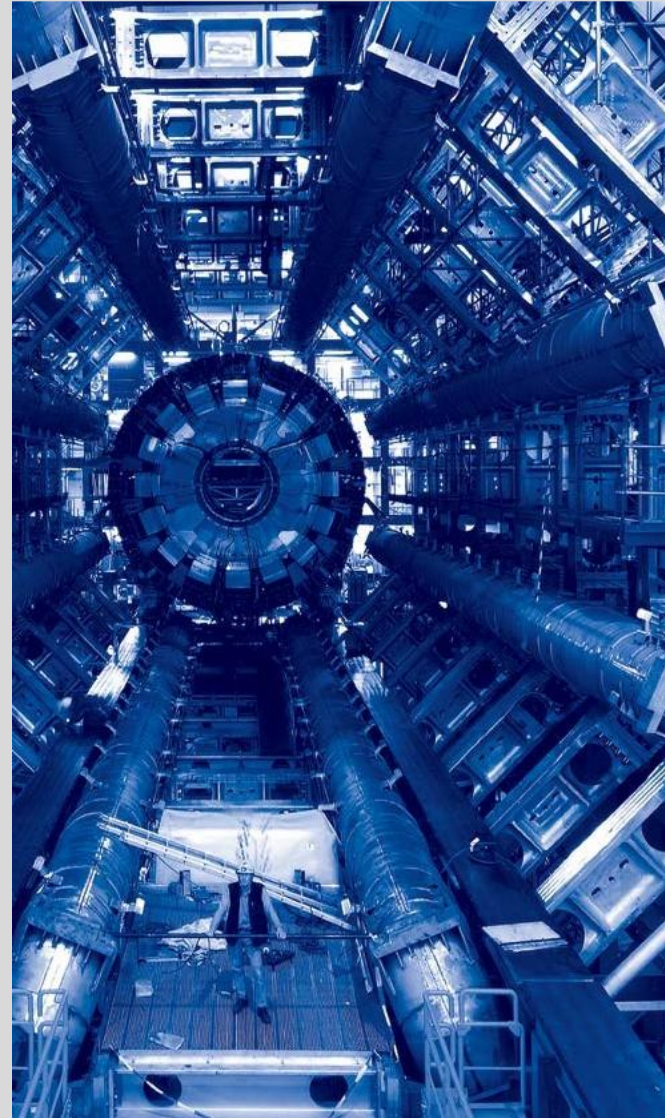
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Experimental High Energy Physics

The Experimental High Energy Physics group at the Technion works predominantly on the ATLAS experiment at CERN.

A few years ago my Team was heavily involved in the search and discovery for the Higgs particle and the measurements of its properties. Currently We are involved in search for Dark Matter and a search for a new physics beyond the Standard Model. We're also working on the upgrade of our detector to be installed in 2021.



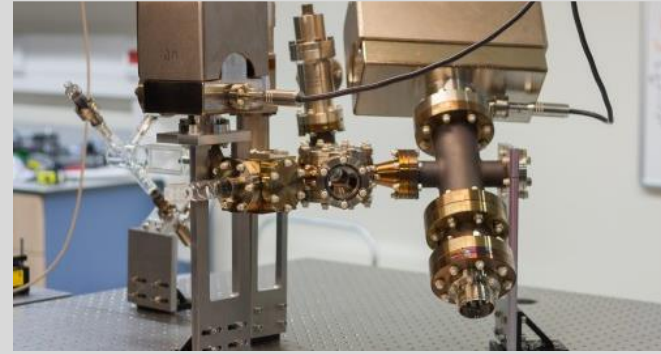
Yoav Sagi

Experimental Many-body Physics with Ultracold Fermi Gases

We utilize lasers, magnetic fields, and electromagnetic radiation to cool neutral fermionic atoms very close to absolute zero, where they form a quantum degenerate gas. Using geometrically shaped light, we engineer the potential landscape the atoms experience. We can then study quantum collective phenomena, such as superfluidity, in different scenarios.

In another experiment, we capture single atoms in microscopic optical traps and use them as the basic build block for quantum computation and quantum simulations.

Our research aims to advance future quantum technologies and explore complex many-body physics relevant to many fields, including condensed matter physics, nuclear physics, and astrophysics.



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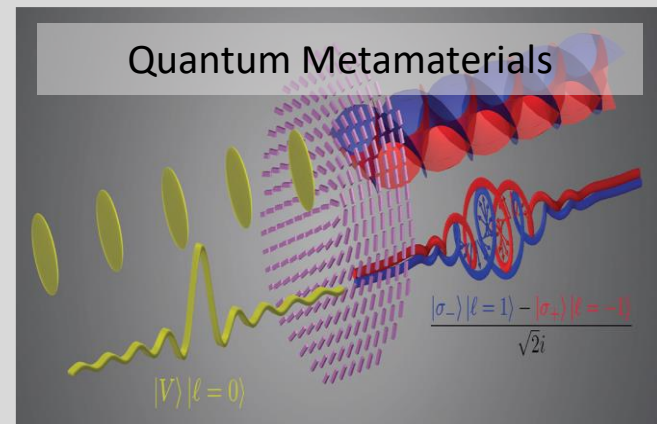
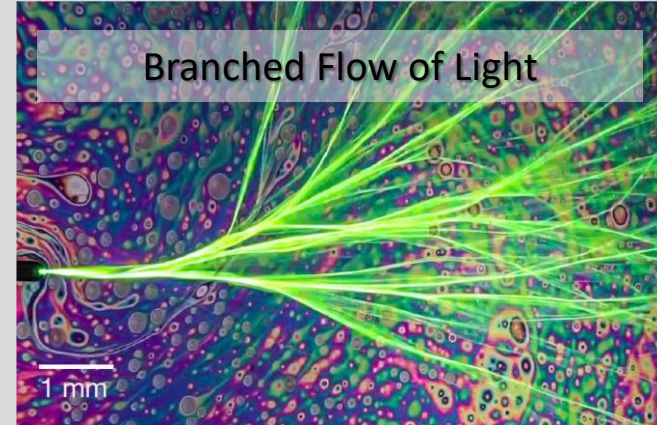
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Mordechai (Moti) Segev

Photonics / Nonlinear Optics / Photonic Quantum Simulations / Photonic Topological Insulators / Light and Disorder (Anderson Localization, Hyper-Transport, etc.) / Branched Flow of Light / Photonic Time-Crystals / Super-resolution in Imaging, Pulse Recovery and Quantum Information

My group is involved in research in a variety of areas, ranging from fundamental concepts such as Photonic Topological Insulators and Anderson Localization and Branched Flow of Light to projects with direct impact on applications, such as Subwavelength Imaging and Super-Resolution in quantum systems, and our invention of the Topological Insulator Laser.

Over the years my group has opened several fields of research, and many times we changed directions when a profound new idea came up. If I am to characterize the research in my group in a single sentence, I would say "think beyond the horizon". We are always after original ideas.



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Theoretical Particle Physics

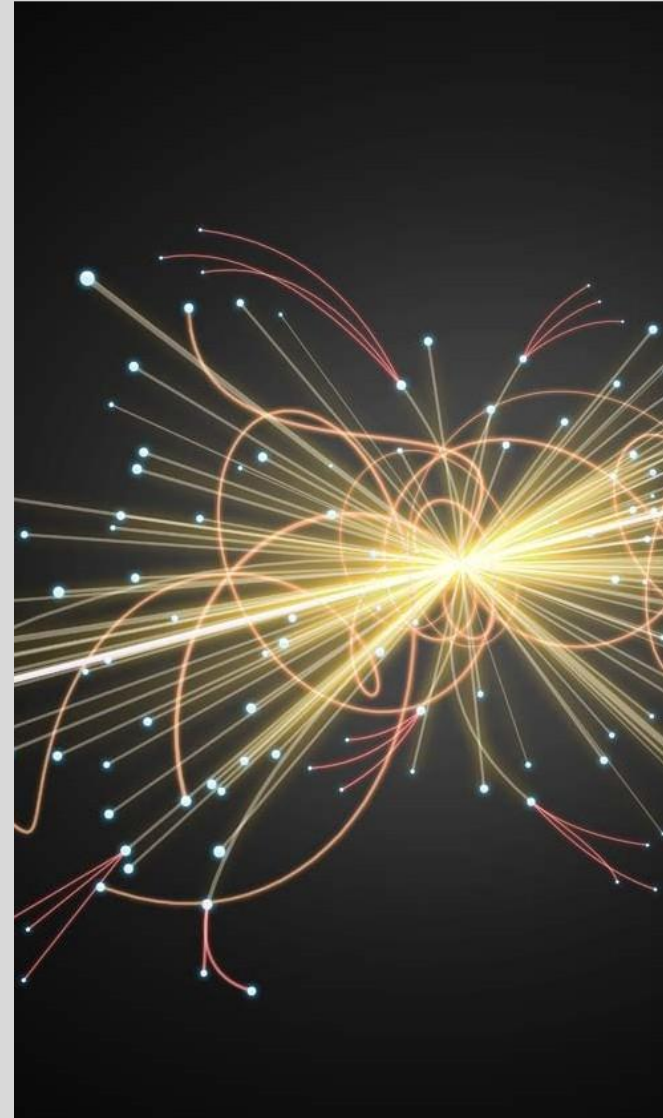
Are there new fundamental particles beyond the known quarks, leptons and gauge bosons?

What sets the mass of the Higgs? Why is the weak force so much stronger than gravity?

What is dark matter? Why is the electron so much lighter than the tau?

Are bosons and fermions related by an (approximate) symmetry—supersymmetry?

My research involves new theoretical approaches to these questions, with a strong emphasis on their possible tests at the many experiments now available: from the LHC, to dark matter detectors, and precision measurements of the properties of the fundamental particles.



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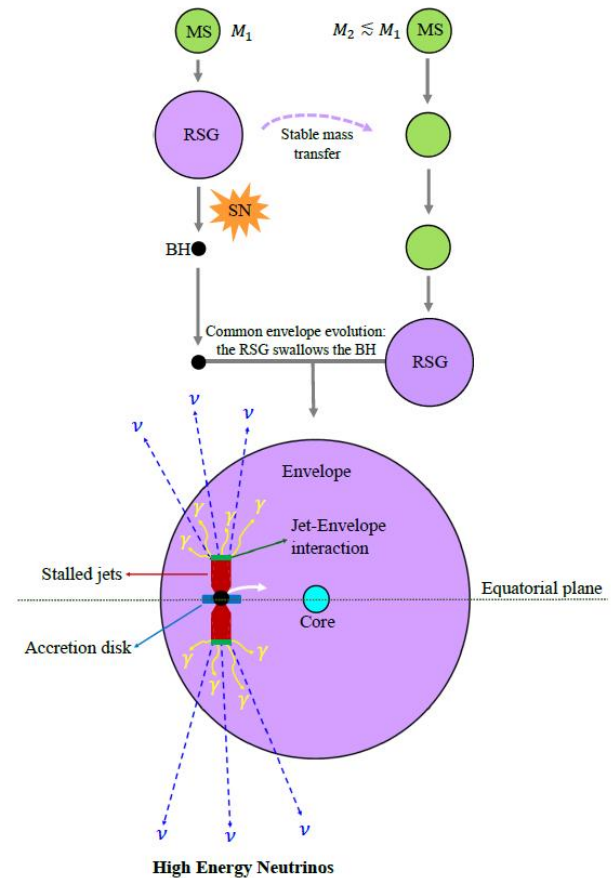
Fundamental Aspects of Soft Matter and Biophysics

Those include molecular interactions, water structure and its role in biological processes with emphasis on the crowded environment found in cells, physics of short range interactions, phase transitions in nanometric volumes, and the effect of water granularity on Coulomb interactions at short distances. The aim is elucidation of fundamental phenomena observed in diverse natural and technological systems. The study of atomic scale structure and molecular forces in water is facilitated by a new type of world-record high resolution atomic force microscopes built in-house for the task. The experimental results are analyzed by advanced tools of statistical mechanics and other branches of physics.



Astrophysics

I am an astrophysicist conducting theoretical research on a rich variety of objects: Supernovae of exploding massive stars; The progenitors of Supernovae Ia (exploding white dwarfs); Merger of white dwarfs; The shaping of clouds around dying stars including planetary nebulae; The influence of planets on stellar evolution; Violent mass transfer between stars. In many cases, one of the stars launches jets that play major roles in stellar evolution and explosions.



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Particle Physics Phenomenology

I am interested in different topics of high energy phenomenology with a focus on physics beyond the standard model. My research aim is to answer fundamental questions about elementary particles and interactions. Among my research topics are LHC physics, Higgs physics, flavour physics, dark matter and low energy probes of new physics.

Currently, I explore novel methods to discover physics beyond the standard model at different energy scales, from high energy colliders (such as the LHC) to low energy precision tests (for example tabletop experiments).



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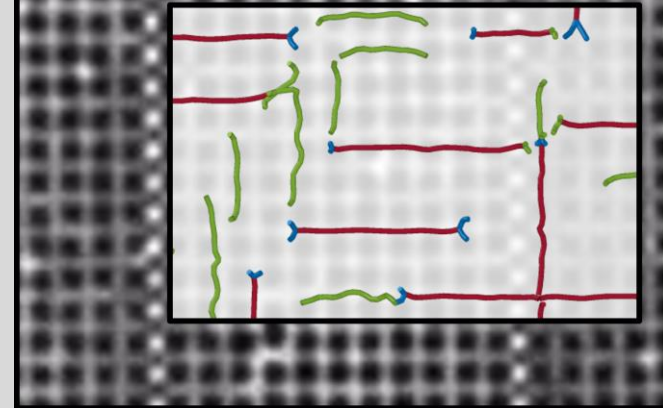
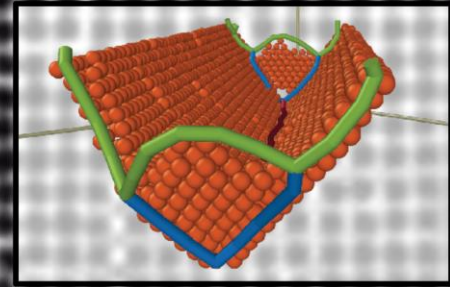
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Experimental soft condensed matter

My research revolves around understanding the detailed dynamics of non-equilibrium mechanical systems where complexity emerges due to the coupling of a large range of spatial and temporal scales. How friction begins and how materials break are examples of such problems. Recently, our group has focused on different aspects of yet another long-standing question – how do crystals flow? The plastic (irreversible) flow of crystals is fascinating as it emerges from a complex collective behavior of topological line defects in the crystalline structure called dislocations. To understand the dynamics of these strongly interacting objects, we use colloidal rather than atomic crystals. The micron size of the colloidal particles allows us to visualize the deformation process in unprecedented detail by harnessing optical rather than electron microscopy.



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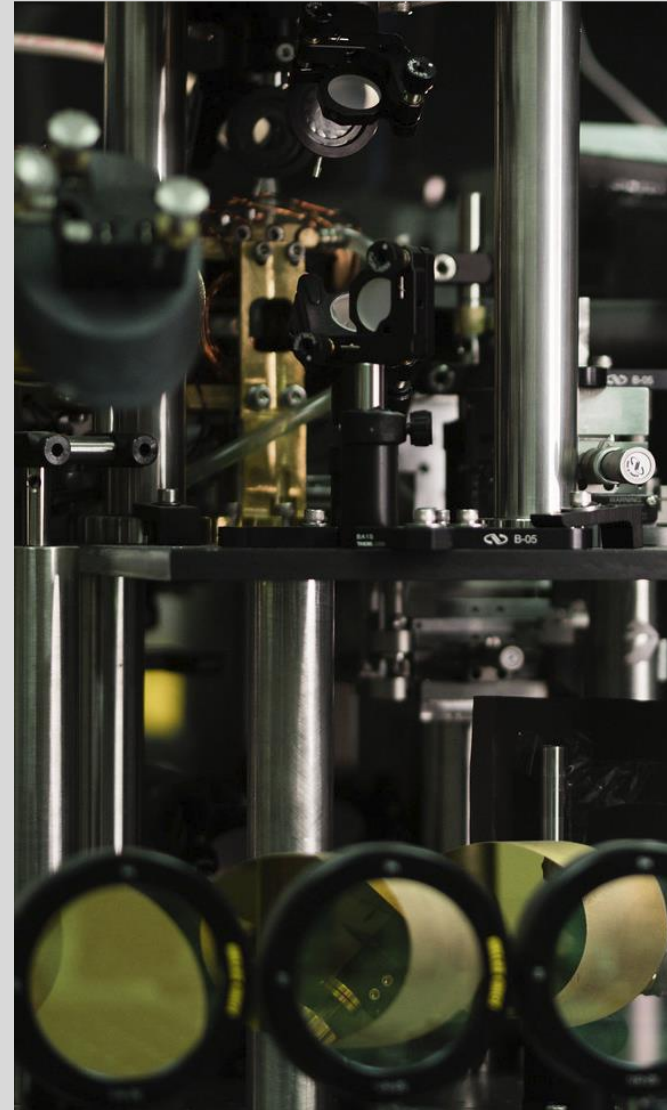
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Jeff Steinhauer

Bose-Einstein Condensation, Analogue Black Holes, Atomic Physics

My group's research focuses on quantum and mean-field aspects of Bose-Einstein condensation. In many cases, we study important analogies between Bose-Einstein condensates and other areas of physics. In recent years, we have focused on Hawking radiation in black hole analogues. Now, we would like to observe beyond-semiclassical effects in analogue black holes, where the analogue of gravity itself becomes quantum.



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Shlomit Tarem

Experimental Elementary Particle Physics

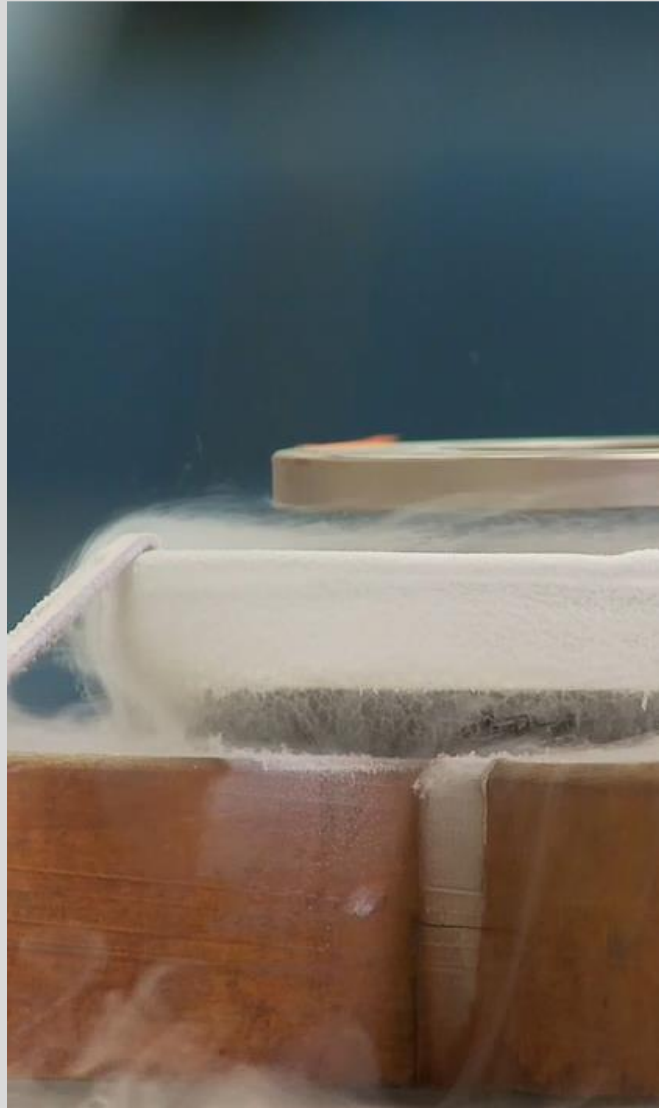
I currently work in the Atlas experiment at the Large Hadron Collider (LHC), which collides protons at a center-of-mass energy of 13 TeV. With Technion students we contributed to the construction of the Atlas detector, the trigger which selects collisions with energetic muons, and muon reconstruction. We also led the data analysis searching for long-lived charged particles, such as the stau, the supersymmetric partner of the tau lepton. This hypothetical new particle would be a sign for physics beyond the standard model, but we did not find it yet. I currently continue to search for the stau and additional long-lived particles at higher energies than before and also work on an upgrade of the detector.



Condensed Matter Theory (topological Order, Entanglement, Geometry of Condensed Matter, Superconductivity)

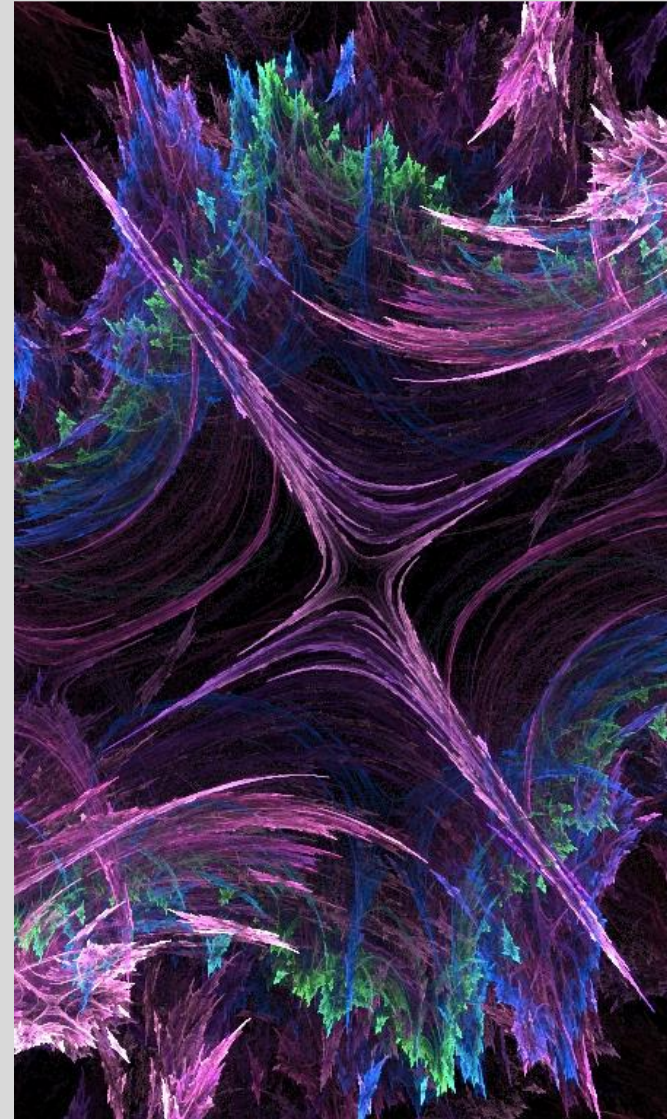
I am interested in quantum as well as classical condensed matter (such as geometry of liquid crystals) but I have been working mainly on quantum condensed matter and entanglement. When I learned about quantum mechanics, I thought it was really interesting that things behave differently depending on what one measures, and since then, I have wanted to find more examples of surprising phenomena in quantum mechanics.

One of the topics I am most excited about is understanding zero point motion in condensed matter, and how it is different from thermal motion. I am using a method based on relativistic field theory to calculate probability distributions of spin in a magnet disordered due to quantum fluctuations. I am also interested in topological phases, stable structures like vortices and solitons that can form in Bose condensates or superconductors (or liquid crystals), and fractionalized excitations.



Theoretical High Energy Physics

My research focuses on applying string theory and field theory techniques to a variety of systems ranging from heavy ion collisions through relativistic hydrodynamics, superfluids, and steady states to entanglement. My recent work has focused on non local quantum field theories which may manifest themselves in condensed matter systems, a relation between black holes and hydrodynamics, universal effective actions for out-of-equilibrium dynamics, the manifestation of anomalies in many-body physics, and possible manifestations of quantum gravity in quantum field theory.



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