A1: Zaijong Hwang, University of Massachusetts Boston
Coauthors: Frank Cao, Maxim Olshanii
Unequal mass Newton's Cradles: a new class of integrable systems

Abstract: A string of hard-core point particles undergoing elastic collisions in 1D can form an integrable system even when they are of unequal masses. This talk will introduce a simple example of such an integrable system that consists of three particles with two unequal mass species.

A2: Ori Hirschberg, Technion
Coauthors: David Mukamel, Gunter M. Schutz
Emergent Motion Of Condensates In Mass Transport Models

Abstract: Condensation phenomena, in which a finite fraction of the "mass" in a macroscopic system is concentrated in a microscopic fraction of its volume, are rather common in nature. Examples include the formation of traffic jams in transportation systems, the clustering of particles in shaken granular gases, the emergence of macroscopically-linked hubs in complex networks and many others. In this talk I will examine the emergent dynamics of the condensate in such systems and report that quite generically the condensate in asymmetric systems develops a drift motion. The mechanism driving this motion is explained using a simplified toy model.

A3: Ohad Shpielberg, Technion
Coauthors: Eric Akkermans

Abstract: A stability analysis of out of equilibrium and boundary driven systems is presented. It is performed in the framework of the hydrodynamic macroscopic fluctuation theory and assuming the additivity principle whose interpretation is discussed with the help of a Hamiltonian description. An extension of Le Chatelier principle for out of equilibrium situations is presented which allows to formulate the conditions of validity of the additivity principle. Examples of application of these results in the realm of classical and quantum systems are provided.

A4: Misha Shvartsman, University of St. Thomas
Coauthors: Pavel Bělík, Douglas P. Dokken, Kurt Scholz
On Thermodynamic Balance In Tornado Theory

Abstract: We explore the energy balance in a thunderstorm, in particular, how energy is redistributed on a local level inside a tornado-like flow.

A5: Simon Thalabard, Umass Amherst
Coauthors: Bruce Turkington
An Optimal Closure for Turbulent Flows

Abstract: I will describe an ``optimal closure framework” to describe the large scale
dynamics of decaying turbulence, that does not rely on a phenomenological modeling
of the viscous damping. The statistical closure employs a Gaussian model for the
turbulent scales, with corresponding vanishing third cumulant, and yet it captures an
intrinsic damping. The key to this apparent paradox lies in a clear distinction between
true ensemble averages and their proxies, most easily grasped when one works
directly with the Liouville equation rather than the cumulant hierarchy.

A6: David Wolpert, Santa Fe Institute
Extending Landauer’s Bound to Arbitrary Computation

Abstract: Recently there has been great progress in bounding the thermodynamic
work required to perform any computation whose output is independent of its input,
e.g., bit erasure. These bounds depend on fine-grained details of the physical
computer that implements the computation. Here I extend these results to bound the
work required for any computation, even one whose output depends on its input. I use
this extension to show that if the computer implementing the computation will be re-
used, then the work bound depends only on the dynamics of the logical variable under
the computation, with no dependence on the physical details of that computer. This
establishes a formal identity between the thermodynamics of (re-usable) computers
and theoretical computer science. As an illustration of this identity, I use it to prove
that the work needed to compute a bit string σ on a Turing machine M is kBT ln(2) ×
[Kolmogorov complexity of σ + log of the (Bernoulli) measure of the set of strings that
compute σ + log of the halting probability of M].

A7: Ben Webb, Brigham Young University
Coauthors: E.G.D. Cohen
Rigorous Results for a New Class of Nonplanar Lorentz Lattice Gas

Abstract: In the study of Lorentz Lattice Gas (LLG) most rigorous results are
restricted to 1-d and 2-d planar lattices. As an intermediate step to understanding
higher dimensional LLGs, we consider the motion of a particle on a number of
nonplanar 2-d lattices whose sites are randomly occupied by scatterers that
deterministically rotate the particle to its left or right depending on the rotator's
orientation. We find that the particle's motion is qualitatively similar to the motion
observed on certain planar lattices, suggesting there may be ways to adapt, in certain
cases, the theory of low-dimensional LLGs to higher dimensional systems.

A8: Dimitri Petritis, University of Rennes 1
Coauthors: Massimo Campanino
Type Transition Of Simple Random Walks On Randomly Directed Regular Lattices

Abstract: Simple random walks on a partially directed version of $\mathbb{Z}^2$ are
considered. More precisely, vertical edges between neighbouring vertices of
$\mathbb{Z}^2$ can be traversed in both directions (they are undirected) while
horizontal edges are one-way. The horizontal orientation is prescribed by a random
perturbation of a periodic function, the perturbation probability decays according to a
power law in the absolute value of the ordinate. We study the type of the simple random walk, i.e. its being recurrent or transient, and show that there exists a critical value of the decay power, above which it is almost surely recurrent and below which it is almost surely transient.

A9: Yao Li, University of Massachusetts Amherst
Coauthors: Lili Hu
A Fast Kinetic Monte Carlo Simulation Method

Abstract: Kinetic Monte Carlo method is used to simulate a large class of Markov jump processes arising in statistical mechanics and other scientific/engineering fields. In this talk, I will introduce a novel exact simulation method, called the Hashing-Leaping method (HLM), for the exact simulation of these Markov process. Under suitable condition, the computational cost of this method is a constant, independent of the scale of the Markov jump process. The main idea of the HLM is to repeatedly implement a hash-table-like bucket sort algorithm for all times of occurrence covered by a time step with length $\tau$.

A10: Flora Koukiou, Cergy-Pontoise University
The Freezing Property For Gaussian Models

Abstract: We discuss the freezing property for Gaussian Models in relation with the entropy of the associated Gibbs measures.

A11: Robert Ziff, University of Michigan
Coauthors: Hao Hu and Yougin Deng, University of Science and Technology of China
Holes In Percolation Clusters

Abstract: For different percolation models, we did simulations to observe holes in the largest cluster, and holes in the largest backbone cluster. We find that the distribution of the size of the holes follows a power law distribution, the dimension of the holes is 2, and a general hyperscaling relation is satisfied. For site percolation on both the triangular and the square lattice, and bond percolation on the square lattice, it is found that the largest hole occupies exactly half of the lattice sites, which follows by a symmetry argument. We also define a percolation model on sites in the holes -- a kind of recursive percolation. We find a critical line, on which the dimension of clusters formed in the holes is also 2.

A12: Eugene Kolomeisky, University of Virginia
Coauthors: J. P. Straley and D. L. Abrams
Atomic Collapse, Screening In Bilayer Graphene And Flat Thomas-Fermi Atom

Abstract: Undoped bilayer graphene is a two-dimensional semimetal with hyperbolic in the momentum low-energy excitation spectrum. As a result screening of an external charge exceeding a critical value $Z_{c}e$ is accompanied by a reconstruction of the ground state: valence band electrons (for $Z>0$) are promoted to form space charge around the external charge while the holes leave the physical picture. This resembles the situation in the monolayer graphene, but unlike the latter, the bilayer screening response for $Z >> Z_{c}$ is described by strictly linear Thomas-Fermi theory which predicts that material's static dielectric response is identical to that of the two-dimensional electron gas in the long-wavelength limit. As a byproduct we also solve
the problem of flat Thomas-Fermi atom embedded into three-dimensional space.

**A13: Irina Navrotskaya, University of Pittsburgh**
Differentiability of the inverse (from density to potential) map and its applications to theory of liquids

Abstract: Let us consider a system of identical particles with the total energy \( W + U \), where \( W \) is a fixed scalar function, and \( U \) is an additional internal or external potential in the form of a sum of \( m \)-particle interactions \( u \). The inverse conjecture states that any positive, integrable function of \( m \) particle coordinates \( \rho \) is the equilibrium \( m \)-particle density corresponding to some unique potential \( u \). This conjecture has now been proved for \( m \geq 1 \) for both canonical and grand canonical ensembles [1, 2, 3, 4]. In the grand canonical formulation, the inverse map is also differentiable for \( m \geq 1 \). (The problem of differentiability in the canonical formulation is much more subtle because the integral of \( \rho \) is a constant [5].) Existence and differentiability of the inverse map for \( m \geq 2 \) provides the basis for the variational principle on which generalizations to density functional theory can be formulated. For example, a generalized Ornstein-Zernike equation (one for every \( m \)) connecting the \( 2m \)-particle direct correlation function and \( 2m, \ldots, m \)-particle densities can be constructed. (This generalization is different from the one considered by Stell.

**A14: Bruce Miller, Texas Christian University**
Coauthors: Cameron Langer
Regular and Chaotic Motion of a Gravitational Billiard in a Cone

Abstract: We study the nonlinear dynamics of a three dimensional billiard in a constant gravitational field colliding elastically with a linear cone. We derive a two-dimensional Poincare map with two parameters, the half angle of the cone and the component of the billiard’s angular momentum parallel to the symmetry axis. We demonstrate several integrable cases of the parameter values, and analytically compute the system’s fixed point, analyzing the stability of this orbit as a function of the parameters as well as its relation to the physical trajectory of the billiard. Next, we explore the phase space of the system numerically. We find that for small values of the angular momentum the conic billiard exhibits behavior characteristic of two-degree-of-freedom Hamiltonian systems with a discontinuity, and the dynamics is qualitatively similar to that of the wedge billiard, although the correspondence is not exact. As we increase the angular momentum the dynamics becomes, on the whole, less chaotic and the correspondence with the wedge billiard is lost. In common with the wedge billiard, we anticipate that modifications of the cone system will prove valuable for experimental investigation, both with atoms at low temperature and driven billiards. arxiv 1507.06693

**A15: Alex Blumenthal, Courant Institute, NYU**
Coauthors: Jinxin Xue and Lai-Sang Young
Lyapunov Exponents For Random Perturbations of Some Prototypical 2D Maps

Abstract: I will present results showing that the introduction of sufficiently large random perturbations can be used to drastically simplify the estimate of Lyapunov exponents. Outside the uniformly hyperbolic setting, estimating Lyapunov exponents for deterministic maps is profoundly difficult. Even when a given map is
“predominantly hyperbolic”, in the sense that it exhibits strong expansion on a large (noninvariant) subset of phase space, there is no guarantee that Lyapunov exponents will reflect this expansion on any positive Lebesgue measure subset of phase space. On the other hand, randomizations can be used to steer trajectories with high probability: we apply this principle to random perturbations of a broad class of “prototypical” two-dimensional maps exhibiting strong expansion. Our results are applicable to many well-known examples of two-dimensional systems, e.g. Henon-like maps and the Chirikov Standard Map.

A16: Nandor Simanyi, University of Alabama at Birmingham
Coauthors: Caleb C. Moxley
Non-commutative rotation vectors for toroidal billiards

Abstract: We give a brief presentation of the homotopical rotation vectors that we introduced for toroidal billiards. Some basic properties of these rotation vectors will be shown for two cylindrical billiards that are known to be chaotic.

A17: Jonathan Mattingly, Duke University
Coauthors: David Herzog, Iowa State
Stabilization By Noise, Nonequilibrium steadystates and Intermiticy

Abstract: I will consider a family of simple planer ODEs which have unstable trajectories, namely \( \dot{z} = z^n + L.O.T \) on the complex plane. Adding noise stabilizes the systems and produces a unique stationary state. The delicate balance of the instability and the noise produces a steady state with a number of interesting properties. (1) It has polynomial tails (2) it mixes exponentially fast at a rate uniform in the initial condition (3) the steadystate has a nontrivial flux and asymptotically understandable intermittent behavior. The analysis turns on a systematic construction of a Lyapunov function in a principled (sharp) way. This generalizes and extends some work of Krzysztof Gawędzki, David Herzog, and Jan Wehr and of Athreya, Kolba, and Mattingly on a special case of this model \( \dot{z} = z^2 \)
B1: Maxim Zyskin, Rutgers University
Coauthors: Gareth Parry, University of Nottingham
Discrete Structures In Continuum Description Of Defective Crystals

Abstract: Davini description of a defective crystal involves 3 continuum 'lattice vector' fields and a scalar dislocation density matrix. Such description allows elastic and plastic deformations of a crystal. Under a constitutive assumption that energy density depends on dislocation density and its first order derivatives, the Lie algebra of lattice vector fields is finite dimensional. In low spatial dimensions, such algebras may be classified. Discrete structures appear as discrete subgroups of corresponding Lie groups. (That includes crystal lattices as a particular case).

B2: Nasir Gankihodjaev, International Islamic University
Ising model with competing "Uncle-Nephew" Interaction

Abstract: Ising models on the Cayley tree with competing interactions has recently been considered extensively because of the appearance of nontrivial magnetic orderings. We consider Ising model on the semi-infinite Cayley tree with competing interaction up to third-nearest-neighbor generation with spins belonging to the different branches of the tree and investigate phase diagram of this model. Previously, da Silva and Coutinho studied the Ising model on a Cayley tree of arbitrary order with competing interactions between the first-, second- and third-nearest-neighbor interactions spins belonging to the same branch. The authors justified that the inclusion of the third-nearest-neighbor competing interaction is essential for the presence of stable modulated phases. For considered model in addition to the expected ferromagnetic, anti-ferromagnetic and paramagnetic phases, we present a new paramodulated phase.

B3: Ayse Yesil, Bilkent University
Coauthors: Cemal Yalabik
Strong Frequency Dependence on Over-damped Systems

Abstract: Strong frequency dependence is unlikely in diffusive or over-damped systems. When exceptions do occur, such as in the case of stochastic resonance, it signals an interesting underlying phenomenon. We find that such a case appears in the motion of a particle in a diffusive environment under the effect of periodically oscillating retarded force emanating from the boundaries. The amplitude for the expectation value of position has an oscillating frequency dependence, quite unlike a typical resonance. We first present an analysis of the associated Fokker-Planck equation, then report the results of a Monte Carlo simulation of the effect of a periodic perturbation on a totally asymmetric simple exclusion process (TASEP) model with single species. This model is known to exhibit a randomly moving shock profile, dynamics of which is a discrete realization of the Fokker-Planck equation. Comparison of relevant quantities from the two analyses indicate that the same phenomenon is apparent in both systems.
**B4: David Rogers, University of South Florida**  
Maximum Transition Entropy - A Causal, Canonical, Model for Nonequilibrium Statistical Mechanics

Abstract: We present the defining equations for MaxTrans. This is an adaptation of Jaynes' Maximum Caliber that maintains causality. We show how the derivatives of a time- and space- local, kinetic partition function with respect to external forces give the conditional average fluxes. MaxTrans both derives the generalized Langevin equation, and provides a means for predicting energy and entropy flows induced by applied forcing.

**B5: Vyacheslav Somsikov, National Academy of Sciences of Ukraine**  
What Is Deterministic Mechanism Of Irreversibility

Abstract: The dynamics of a system is reversible in accordance with the formalism of classical mechanics, while all real processes are irreversible. The fact that classical mechanics is reversible means either the incompleteness of classical mechanics, or the need to expand the formalism of classical mechanics by removing the limitations under which it was built. The goal of this report is to explain irreversibility within the laws of classical mechanics by removing some of the limitations. The dynamics of a system of hard discs, as well as a system of potentially interacting material points (MP), had been studied in order to solve the problem. We also searched for the limitations of classical mechanics, responsible for irreversibility [1, 2]. Studies of the dynamics of discs was found that a system of hard discs, rather than individual discs, should be studied in order to find irreversibility. This is due to the fact that irreversibility is associated with the transformation of the system’s kinetic energy into its internal energy. So the principle of dualism of symmetry should be used in order to describe the dynamics of bodies. This principle implies that the dynamics of a body is described by two types of symmetry: the symmetry of space and the symmetry of the body itself. That is why we should split the body’s energy into kinetic and internal components in order to describe its dynamics. (More on website)

**B6: Natalia Prykarpatska, AGH University of Science and Technology of Krakow**  
Coauthors: Anatolij K. Prykarpatski  
The Two-liquid Kinetic Boltzmann-Vlasov Equation And The Related Hydrodynamic Flow

Abstract: A two-component particle model of Boltzmann-Vlasov type kinetic equations in the form of special nonlinear integro-differential hydrodynamic systems on an infinite-dimensional functional manifold is discussed. We show that such systems are naturally connected with the nonlinear kinetic Boltzmann-Vlasov equations for some one-dimensional particle flows with pointwise interaction potential between particles. A new type of hydrodynamic two-component Benney equations is constructed and their Hamiltonian structure is analyzed.

**B7: Jaewook Joo, University of Tennessee**  
Network Architectural Conditions for Noise-induced Biochemical Oscillators

Abstract: In biological signaling or regulatory networks, it is of great interest to understand the mechanisms governing the oscillatory behaviors and their biological
implications, and elucidate the controllable conditions. We are keen to elucidate the relationship between the network structural properties and the noise-induced oscillations. We propose a conjecture that the existence of feedback loops in a biochemical reaction is the necessary topological condition for noise-induced oscillation, i.e., the biochemical reaction networks without any feedback loops cannot generate noise-induced oscillation at all. In this talk, we will present a part of our work to prove this conjecture. This work is still in progress.

B8: Megan Khoshyaran, Economics Traffic Clinic – ETC
Pocket Stability In A Complex System

Abstract: Consider a complex system. Consider within this complex system a pocket of stable sub-system. The question that is analyzed in this paper is that how an stable sub-system can survive in an environment that does not tolerate stability. The entropy of the complex system is higher than the sub-system. The difference in entropy should cause the breakdown of the stable sub-system by corrupting it. How does the stable-subsystem resist this corruption. Does the sub-system have a finite existence. Is the entropy of the stable sub-system different from the complex system. It is shown that for a stable sub-system to survive, the sub-system must build a clear boundary. This boundary consists of a compact set of sentinels. The function of these sentinels is to maintain the order and stability of the sub-system by assimilating information into the sub-system in such a way that the sub-system evolves towards a new and better (longer lasting) equilibrium state. The sentinels do not cause phase change in the complex system. (More on website)

B9: Amy Graves, Swarthmore College
The Importance Of The Follow Factor In A Social Force Model Of Bidirectional Flow

Abstract: The social force model of Helbing, Viscek and others allows one to model self-propelled particles via molecular dynamics (MD) simulations. Here, we present MD results for bidirectional flow: two species of particle with opposite preferred directions, traversing a passage containing a constriction (doorway). The "follow factor" - sometimes interpreted as the degree of "panic" among pedestrians - sets the degree to which particles match the direction of motion of nearby neighbors. When the follow factor is different for the two species, there can be significantly different rates of transport. Information entropy may be used to characterize this system.

B10: Partha Goswami, D.B. College,University of Delhi
Carrier Dynamics Of A Quantum System And Spectral Weight Density

Abstract: The spectral weight density (SWD), dependent on temperature T and the doping level p, is related to the real part of the longitudinal optical conductivity of a quantum system like hole-doped or electron-doped cuprate and provides valuable information on the evolution of the carrier dynamics with T and p. To explain, we consider the former system characterized with the density wave instabilities. At constant p, on lowering the temperature, if coexistent superconducting solution(SCS) emerges with the SWD available, for the corresponding pairing, undergoing considerable change, one may conclude that the SCS is not a bi-product of the existing density wave orders.
**B11: Xinliang An, Rutgers University**
Coauthors: Partially with Jonathan Luk and partially with Xuefeng Zhang
On Gravitational Collapse in General Relativity

Abstract: In the process of gravitational collapse, singularities may form, which are either covered by trapped surfaces (black holes) or visible to faraway observers (naked singularities). In this talk, I will present three results with regard to gravitational collapse. The first is a simplified approach to Christodoulou’s monumental result which showed that trapped surfaces can form dynamically by the focusing of gravitational radiation from past null infinity. We extend the methods of Klainerman-Rodnianski, who gave a simplified proof of this result in a finite region. The second result extends the theorem of Christodoulou by allowing for weaker initial data but still guaranteeing that a trapped surface forms in the causal domain. In particular, we show that a trapped surface can form dynamically from initial data which is merely large in a scale-invariant way. The second result is obtained jointly with Luk. The third result extends Christodoulou’s celebrated example on formation of naked singularity for Einstein-scalar field system under spherical and self-similar symmetry. With numerical and analytic tools, we generalize Christodoulou’s result and construct an example of naked singularity formation for Einstein vacuum equation in higher dimension. The third result is obtained jointly with Zhang.

**B12: Michael Kiessling, Rutgers University**
Coauthors: R. Nerattini, J. Brauchart
On Minimal Average Riesz Energies Of N Points On A Sphere

Abstract: Riesz pair energies are essentially powers of the 3D Coulomb pair energy. By averaging over all pairs in an N point configuration one obtains the mean pair energy of a configuration. We have analyzed empirical data lists of putatively minimal average Riesz pair energies as a functions both of the Riesz power parameter, and of N. We thereby have discovered some empirical monotonicity results which, if proved, will provide a necessary criterion of minimality that can be used to test empirical data.

**B13: Soeren Petrat, IST Austria**
Coauthors: Volker Bach, Sebastien Breteaux, Peter Pickl, Tim Tzaneteas
Derivation of Mean-Field Dynamics for Fermions

Abstract: I present recent results about the derivation of the time-dependent Hartree(-Fock) equations from the Schroedinger equation for fermions in a mean-field limit. I introduce and discuss a new scaling limit for such a derivation and present the rigorous results. These results are obtained by generalizing the method developed by Pickl for bosonic systems to fermionic systems. I will briefly sketch the basic ideas and the advantages of this method.

**B14: David Mitrouskas, Munich University, LMU, Germany**
Coauthors: Maximilian Jeblick, Soeren Petrat and Peter Pickl
Effective Dynamics Of A Tracer-particle Coupled To The Ideal Fermi Gas In The High Density Limit

Abstract: A tracer-particle coupled strongly to an ideal Fermi gas at zero temperature is considered. We show that for d=1 and d=2 spatial dimensions the dynamics of the
interacting system converges for any fixed time $t>0$ to the free dynamics in the high density limit of the gas. The result is noteworthy because in the considered regime, i.e., for large density and strong coupling, one would expect the movement of the tracer-particle to be slowed down rapidly due to the large number of possible collisions with gas particles.

**B15: Victor Chulaevsky, Universite de Reims**  
Coauthors: Yuri Suhov  
Scaling Analysis And KAM Techniques In Anderson Localization

Abstract: We review existing techniques and present some new results on Anderson localization in disordered quantum systems with and without interaction.

**B16: Vadim Kaloshin, University of Maryland**  
Coauthors: O. Castejon, M. Guardia, J. Zhang, and K. Zhang  
Stochastic Arnold Diffusion Of Deterministic Systems

Abstract: In 1964, V. Arnold constructed an example of a nearly integrable deterministic system exhibiting instabilities. In the 1970s, physicist B. Chirikov coined the term for this phenomenon “Arnold diffusion”, where diffusion refers to stochastic nature of instability. One of the most famous examples of stochastic instabilities for nearly integrable systems is dynamics of Asteroids in Kirkwood gaps in the Asteroid belt. They were discovered numerically by astronomer J. Wisdom. During the talk we describe a class of nearly integrable deterministic systems, where we prove stochastic diffusive behaviour. Namely, we show that distributions given by deterministic evolution of certain random initial conditions weakly converge to a diffusion process. This result is conceptually different from known mathematical results, where existence of “diffusing orbits” is shown.

**B17: Philip Kopel, UC Davis**  
Linear Statistics of Non-Hermitian Random Matrices

Abstract: I will present a recent central limit theorem for the linear eigen-statistics of random matrices with independent entries but without symmetry conditions, and discuss some remaining open problems in the area.

**B18: Marcelo Terra Cunha, University of Campinas**  
On Self-catalytic Conversion of Pure Quantum States

Abstract: I will present ideas and results of a joint work with Cristhiano Duarte and Raphael Drumond (arXiv:1504.06364). For this I will quickly introduce catalysis, self-catalysis, and then make questions about typicality of such phenomena, showing the partial answers we arrived at.