**Clarkson**
**U N I V E R S I T Y**
*defy* convention ™

**Mathematics Conference and
Competition of Northern New
York (MCCNNY)**

**Potsdam**
1816   THE STATE UNIVERSITY OF NEW YORK

# *A Conference for Undergraduate and Graduate Students in Northern New York*

*February 28 and March 1, 2014*
*Clarkson University*
*8 Clarkson Ave, Potsdam, NY 13699-5815*

# Schedule

## Friday, Feb 28, 2014, Science Center 360

| | |
|---|---|
| 6:00pm – 6:30pm | Registration |
| 6:30pm – 7:00pm | Keynote Address: Dr. Peter Turner, Science Center 360<br>Title: Why Math Matters |
| 7:00pm – 8:00 pm | *Math Jeopardy!* Emceed by Dr. Blair Madore, SUNY Potsdam (Prizes for winning teams!) |

## Saturday, March 1, 2014, Snell 212, 213, 214

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|---|---|
| 9:00am—9:30am | Registration<br>Outside of rooms Snell 212, 213, 214 |
| 9:15am – 10:00am | Student Poster Competition and Student Activities |
| 10:00am – 10:50am | Research Experience for Undergraduates Panel, Mediator Dr. Katie Fowler, Snell212<br>Career Panels, Mediator Dr. Joel Foisy, Snell213<br>Graduate School Panel, Mediator Dr. Chris Lynch, Snell214 |
| 10:50am – 11:00am | BREAK |
| 11:00am – 11:50am | Research Experience for Undergraduates Panel, Mediator Dr. Katie Fowler, Snell212<br>Career Panels, Mediator Dr. Joel Foisy, Snell213<br>Graduate School Panel, Mediator Dr. Chris Lynch, Snell214 |
| 12:00pm – 1:00pm | LUNCH, Student Center |
| 1:00pm – 1:50pm | Keynote Address: Dr. Lea Jenkins, Clemson University<br>Title: Look for the Mathematics<br>Snell 213 |
| 2:00pm – 3:30pm | Faculty and Associated Colleges Alumni Talks, Snell 213 |
| 3:30pm – 3:45pm | Closing Remarks and Drawing for Door Prizes, Snell 213 |

## Keynote Address 1:

**Dr. Peter Turner**
**Dean of Arts & Sciences**
**Professor, Mathematics & Computer Science**
**Clarkson University**

**Title:** *Why Math Matters*

**Abstract:** The national emphasis on STEM, STEM education and the STEM workforce is meaningless without a strong core of mathematical thinking. The talk will begin with a look at a few places in which mathematics has had a major impact and opens opportunities for worthwhile careers in academia and beyond. Following that introduction, I will discuss some of the recent developments in the mathematics professional community to address STEM Education and Workforce priorities.

## Keynote Address 2:

**Dr. Lea Jenkins**
**Department of Mathematics Science**
**Clemson University**

**Title:** *Look for the Mathematics*

**Abstract:** A recent headline in the New York Times read "$28,000 a Night: Hotels Race to Cater to the Superrich". One of my favorite questions to ask when I read statements like that is not "Who can afford that?" but "Where is the mathematics in here?" If you know how to look for them, mathematics problems can frequently be found inside headlines or front-page stories. In this talk, we will examine some recently documented events and look for the mathematics in each of them. Audience members will be asked to participate and suggest problems "hidden in the headlines".

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## Invited Speakers：

### Dr. Daniel Look, St. Lawrence University

**Title:** *It Came from......the Fourth Dimension!*

**Abstract:** Comic books are rarely used as mathematical resources. However, artistically, comic books have an advantage over other visual media in terms of conveying higher dimensional spaces. We will focus on an issue of Steven Bissette and Alan Moore's *1963 Comics* which features a battle between the character Hypernaut and an invader from "The Fourth Dimension" to explore how the artistic space created by the panels of a comic book lend themselves to portraying higher dimensions.

### Dr. Joseph Skufca, Clarkson University

**Title**: *No Magician's, Please: How to avoid being an illusionist*

**Abstract:** The human visualization system is high bandwidth. In fact, we get more information from vision than from all other senses combined. That information is rapidly process by powerful parallel circuitry that has been optimized for certain types of tasks. As a scientist, when we need to make sense of data, a visualization is often the best choice. However ... the specialized processing that makes us very good at some visual tasks also makes the system vulnerable to certain types of misperception. Magic and illusion is founded upon the performers' ability to exploit those vulnerabilities.

As a good scientist, our job is to NOT be an illusionist. The goal of data visualization is to accurately convey information, not to mislead. In this talk, we will discuss some of the ways in which our visualization and perception systems interact with data visualization along with some tips and techniques on how to avoid becoming a data-illusionist.

### Dr. Daniel Gagliardi, SUNY Canton

**Title:** *Graphic realizations of certain classes of integer sequences*

**Abstract:** A graph G is a realization of a monotone sequence S of positive integers if S is the degree sequence of G. This talk will focus on certain families of sequences in order to determine if they are realizable as graphs, and if so, to provide a method for their construction. In particular, we consider sequences that contain one term repeated thrice with all other terms distinct. We also define properties for integer sequences whose graphic realizations are self-complementary.

Note: This talk is based on work done collaboratively with Jim Defranza (SLU) and John W. Kennedy (Nassau Community College)

## Dr. Robin Locke, St. Lawrence University

**Title:** *Applications of a Poisson Model to Rate Teams and Predict Results in College Hockey*

**Abstract:** The Poisson distribution is often used to describe the behavior of "rare" events in a continuous time frame. A good example is the scoring of a goal in ice hockey. Some questions we will address are

- What is a Poisson distribution and how do we use it to model hockey scores?
- How can we predict the expected scoring rate when Team A plays Team B?
- How can we use past game results to rate the offensive and defensive abilities for all teams – while accounting for strength of schedule?
- Who should win when Clarkson and St. Lawrence play Quinnipiac and Princeton this evening?

We describe how the Poisson model is used in computing the College Hockey Offensive and Defensive Ratings (CHODR - pronounced like the clam soup) that are currently applied to NCAA Division I Men's and Women's teams at http://it.stlawu.edu/~chodr.

## Dr. Jiayuan Lin, SUNY Canton

**Title:** *What is Stanley Depth?*

**Abstract:** In algebra, module is a natural generalization of vector space. In this talk, I will explain an important concept \Stanley depth", which was introduced by Richard Stanley in 1982. He conjectures that for a multi-graded module, its Stanley depth is greater than or equal to its depth. For almost 20 years since Stanley conjecture was proposed, there had been no progress on it. One of the obstacle in cracking Stanley conjecture is that there is no known algorithm to calculate Stanley depth. The turn of the century witnessed a burst of activities on Stanley conjecture. One breakthrough was made by J. Herzog, M. Vladoiu and X. Zheng. By associating a module which is quotient of two monomial ideals of a polynomial ring with a poset, they successfully reduced the computation of Stanley depth to a combinatorial question, that is, to find certain interval partition of the poset. Although many special cases have been confirmed, Stanley conjecture itself is still wide open. In this talk I will give some examples on how one can construct suitable interval partitions to find Stanley depth. Hope this talk is accessible to undergraduate students.

## Dr. Jason Howald, SUNY Potsdam

**Title:** *1/0 is defined.*

**Abstract:** In this talk we explore the meaning of mathematical definition, especially as it applies to problematic cases such as $\frac{1}{0}$ or $\lim_{x \to 0} \sin\left(\frac{1}{x}\right)$ We first survey a few beautiful ideas from Frege, Russell, and Hilbert. Next we critique the everyday mathematicians approach to undefinedness as arising from a basic philosophical confusion. Finally we offer some modern alternatives.

*Panel Discussion on Research Experiences for Undergraduates (REUs)*

*Mediator:* Dr. Joel Foisy, SUNY Potsdam

*Panel Members:*

Dr. Kelly Black, Clarkson University
Justin Foster, Clarkson University
Aaron Morse, SUNY Potsdam
Cervanters Nava, SUNY Potsdam

## Panel Discussion on Graduate School

*Mediator:* Dr. Katie Fowler, Clarkson University

*Panel Members:*

Dr. Erik Bollt, Clarkson University
Xiaojing Fu, MIT
Andrew Davis, MIT
Benjamin Ritz, Clarkson University
Matt Fowler, Clarkson University

## Panel Discussion on Careers in Mathematics

*Mediator:* Dr. Chris Lynch, Clarkson University

**Panel Members:**

Mike Fowler, Clarkson University
Jeff Taylor, Clarkson University
Josh LaFave, SUNY Potsdam

**Note:** The panel discussions will be from 10:00am—10:50am and 11:00am—11:50am on Saturday, March 1st, 2014, in Snell 212, Snell 213, and Snell 214. The second session will be the same topics so people can choose two of the three to attend.

# MCCNNY Student Poster Presentation Abstract

## 8:30am – 10:00am

## New Snell Atrium

| | Speaker | Title |
|---|---|---|
| 1 | Aaron Morse and Cristopher Negron | *On Weakly Diameter-m-Critical Graphs* |
| 2 | Jayesh Bokhiria | *A Longitudinal Analysis for Berry Farmers Using Trade-Off Curves* |
| 3 | Eric Budge and Steve Petramale | *On Counting Triangles in a Graph* |
| 4 | Kathryn Christensen | *Root-Finding Methods* |
| 5 | Justin Foster | *Topic Modeling* |
| 6 | Xiaojing Fu | *Three-dimensional high-resolution simulation of convective mixing* |
| 7 | Kevin Gibson | *Three-dimensional high-resolution simulation of convective mixing* |
| 8 | Jack Holby | *Variations on the Euclidean Steiner Tree Problem* |
| 9 | Veroni Jayawardana | *Factors Associated with the function among individual with Fibromyalgia Syndrome* |
| 10 | Palmer Lao | *Multifactor Authentication using Bayes Factors* |
| 11 | Ellen Lehet | *Virtual Knot Theory: The Forbidden Number* |
| 12 | Candace Liu | *Dynamic Model for Balancing Deer Population and Insurance Funds* |
| 13 | Corey Ostrove | *Simulation Framework for Optimization of Sustainable Farming Practices* |
| 14 | Carrie Rider | *Protein-protein Interaction Detection Using Mixed Models* |
| 15 | Jeffrey Smith | *A Physics-based Thermal Circuit Model for Multi-gate Field Effect Transistor Structures* |
| 16 | Peter Vaillancourt | *A Rigid Body Dynamics Model of a Pogo Stick* |
| 17 | Congzhi Xia | *On the Merrifield-Simmons indices of bicyclic graphs* |

**Aaron Morse, Cristopher Negron** (joint work with Omar de la Cruz Vite, Claire Gibbons, Aaron Morse, Cristopher Negron. Advisor: Joel Foisy)
**Title:** *On Weakly Diameter-m-Critical Graphs*
**Abstract:** A graph G is diameter-m-critical if the diameter of G is m and the deletion of any edge increases the diameter. Diameter-2-critical graphs have been studied extensively in connection with a conjecture of Murty and Simon. We show that a consequence of this conjecture holds. We then generalize the diameter-m-critical graphs to include graphs of diameter less than m. We identify several infinite families of these graphs, classify all such paths and cycles, and discuss some results and conjectures regarding the number of such graphs on n vertices.

**Jayesh Bokhiria** (Joint work with Kathleen Fowler. Advisor: Dr. Kathleen Fowler)
**Title:** *A Longitudinal Analysis for Berry Farmers Using Trade-Off Curves*
**Abstract:** Everyone loves berries but we do not like to see the price increased every time we go to grocery store. Why have the berry prices increased every year? In the previous years, California agricultural practices have stressed the groundwater basin significantly. Hence, the government had also increased water prices dramatically to promote less water usage and stop the overdraft. In this paper, we use predicted water prices and crop parameters in an optimization model that analyzes farming practices over 10 years. The three objectives are to maximize the profit, minimize water usage, and minimize deviation from the current demand. We pose this problem as a multi-objective constrained linear optimization model. We present trade-off curves to help guide decision makers.

**Eric Budge and Steve Petramale**
**Title:** *On Counting Triangles in a Graph*
**Abstract:** Algorithms for counting triangles in massive graphs has been studied intensively. This fundamental tool in network analysis is used, for example, to compute metrics such as the clustering coefficient and transitivity ratio. The degree sequence, S, of a graph, G; is a list of the degrees of the vertices in G in non-increasing order. A finite non-increasing sequence of positive integers S is called a graphic degree sequence if and only if a graph G can be realized using S: This work focuses on degree sequences with a unique triple sequence, a sequence with one term repeated three times and all other terms distinct. Polynomial expressions are given which count the number of triangles in realizations of such graphic unique triple sequences. A recent paper by DeFranza and Newton established that unique triple sequences with $s1 = 4p$ or $4p+3$ and unique triple $UT = [s1/2] + 1$; for $p \in N$ are graphic. This result was extended by DeFranza and Gagliardi to include all possible triples in a given sequence that yield a graphic degree sequence. We use the realization, given in the first result, to count the number of triangles in the graphs. Further, we provide a method for creating realizations for the graphic degree sequences, given by the second result, to count the number of triangles for this family of graphs.

**Kathryn Christensen**
**Title:** *Root-Finding Methods*
**Abstract:** In numerical analysis, fixed-point iterations are an effective method for finding the roots of a function. Starting with an initial guess, the successive outputs of the iteration function will (in most cases) converge to a root of the given function. We will begin by discussing Newton and Halley's methods, then move to their generalization, the Householder method. We will then discuss the benefits of certain methods, in particular in terms of the rates of convergence to a root. Finally, we will observe Newton and Halley's methods in action with an application involving the power generated by plutonium fuel cells as a function of time. Our aim here will be to apply the root-finding methods to that function and estimate the time it will take for a fuel cell to reach a minimum power threshold.

**Justin Foster** (Advisor: Adom Giffin)
**Title:** *Topic Modeling*
**Abstract:** The vast amount of information available today creates an interesting dilemma. Although there is a copious amount of literature about any given subject, sorting through and finding the articles that are specifically pertinent to ones interests is challenging. The idea of topic modeling was introduced to address this challenge. The goal of topic modeling is to develop an automated tool for organizing and managing large corpora. We will demonstrate how Latent Dirichlet Allocation (LDA) is used in addressing this issue with an emphasis on its Bayesian foundation in order to discuss other possibilities of application.

**Xiaojing Fu** (joint work with Luis Cueto-Felgueroso and Ruben Juanes); Faculty Advisor: Ruben Juanes; Graduate Student, Environmental Engineering, Massachusetts Institute of Technology
**Title:** *Three-dimensional high-resolution simulation of convective mixing*
**Abstract:** Dissolution by convective mixing is an essential trapping mechanism during $CO_2$ sequestration. The injected $CO_2$ mixes with brine and creates mixture denser than both initial fluids, leading to a Rayleigh-Benard type instability, which greatly accelerates the dissolution process. While 2D analyses on this phenomenon have elucidated various aspects of this mechanism, full 3D studies are scarce. We present high-resolution, 3D simulations of convective dissolution, and discuss the validity of quantitative results derived from lower-dimensional models.

**Kevin Gibson** (Advisor: Joseph Skufca)
**Title:** *Social Network Consensus: It's not who you know, it's what you are a part of*
**Abstract:** A relatively new area of study in sociology tries to understand how social behaviors can be viewed within the context of social networks. This study focuses on modeling the spread of an idea through social networks, in order to observe the rate in which consensus of the idea is reached. We model these social networks using a representation known as an Affiliation Network, which captures interactions between individuals based on their memberships in various groups (called a two-

mode graph). This structure is compared to a standard social network, where individuals interact directly with acquaintances (called a one-mode graph). The method by which the nodes in these graphs are updated，or hange their idea is known as a voter model. Our research seeks to understand how the size and connectivity structure of the network affects the time to reach consensus in both the one and two mode graphs.

**Jack Holby** (Advisor: Sam Vandervelde)
**Title:** *Geometric Variations on the Euclidean Steiner Tree Problem*
**Abstract:** The Euclidean Steiner Tree Problem (ESTP) attempts to create a minimal spanning network of a set of points by allowing the introduction of new points, called Steiner points. This poster discusses a variation on this classic problem by introducing a single "Steiner line" in addition to the Steiner points, whose weight is not counted in the resulting network. For small sets, we have arrived at a complete geometric solution. We discuss heuristic algorithms for solving this variation on larger sets. We believe that in general, this problem is NP-hard.

**Veroni Jayawardana**, Sumona mondal, Leslie Russek
**Title:** *Factors Associated with the function among individual with Fibromyalgia Syndrome*
**Abstract:** The purpose of this study was to assess the presence of kinesiophobia, or fear of movement, balance disorders and anxiety-related psychological conditions to overall function and activity level. The data for the study were collected by a national internet survey of community-based individuals with fibromyalgia (FM). In this study the dependent variable was Revised Fibromyalgia Impact Questionnaire (FIQR) and independent variables (factors) were Activities-Specific Balance Confidence Scale (ABC), Primary Care Post-Traumatic Stress Disorder Screen (PC-PTSD), Tampa Scale of Kinesiophobia (TSK), Hypermobility (HMS), Vertigo Symptom Scale (VSS-SF), Obsessive-Compulsive Personality Disorder (OCPD), Pain, and Physical Activity. Results indicated function (FIQR) was highly correlated to the ABC, Pain, PTSD, TSK and VSS. Linear-regression model using both the methods Best Subset Regression and Bayesian approach showed that the contribution of significant factors was in expected directions.

**Palmer Lao** (Advisor: Adom Gifin)
**Title:** *Multifactor Authentication using Bayes Factors*

**Ellen Lehet** (Advisor: Dr. Sandy Ganzell)
**Title:** *Virtual Knot Theory: The Forbidden Number*
**Abstract:** This research was conducted by an REU group sponsored by St. Mary's College of Maryland. The research is focused in virtual knot theory, specifically studying an invariant called the forbidden number. This invariant represents the minimum number of forbidden moves, which is a specific manipulation of crossings, necessary for the knot to be reduced to the unknot. The goal of our research was to find the forbidden number for four crossing virtual knots. We did this by untying knots "by hand" and through the help of other invariants. We found exact forbidden

numbers for many knots, but we were also able to get a closer estimation of the forbidden number for nearly every four crossing knot.

**Candace Liu** (Advisor: Kelly Black)
**Title:** *Dynamic Model for Balancing Deer Population and Insurance Funds*
**Abstract:** Insurance companies are tightly regulated but they have to set premiums to balance claims and profits. A coupled model based on stochastic differential equations is derived to simulate the interaction of deer population and vehicles in Athens County, Ohio. The interaction between deer and vehicles is explored to see how insurance companies manage their funds from investments, premiums and claims. The results from the numerical simulations of the models will provide insight to the pricing of premiums.

**Corey Ostrove**, Kathleen Fowler, Matthew Farthing, Stacy Howington, Matt Parno, Eleanor Jenkins, John Chrispell
**Title:** *Simulation Framework for Optimization of Sustainable Farming Practices*
**Abstract:** Modern Agriculture is water intensive and when the wrong crop distributions are selected for a region can lead to depletion of existing aquifers. This can be magnified in the presence of changing climate conditions, severe droughts, and increased demands on resources through urbanization or reduced conservation efforts. When the agricultural region is located near the coast, aquifer depletion leads to salt water intrusion in drinking water wells near shore. This forces water utilities to reallocate water from inland sources, changing both aquifer stresses and water management dynamics. Efficient control of the crop distribution is thereby critical for sustainability and continued profitability of these complex agricultural systems. To this end, the Farm Process (FMP2) package has been incorporated into our simulation tool. FMP2 is a physically based farm process simulator designed to work with the popular United States Geological Survey (USGS) groundwater simulation tool, MODFLOW (MF). This software tool (MF-FMP2) integrates fully coupled groundwater flow with precipitation, stream flow and runoff, and critically, the consumption of water by vegetation. Furthermore, the package allows for water allocation to individual farms from a variety of sources, enabling us to evaluate costs and benefits of different water management systems. Importantly, a variety of crops can be associated with a single farm and entire agricultural regions can be simulated simultaneously. These are critical features missing from our previous simple models, as they allow the optimizer to specify the crop distribution within each individual farm and allow the optimization objective to incorporate important inter-farm hydrologic coupling.
The focus of this work is to use MF-FMP2 as a black-box simulator in conjunction with optimization tools to guide practitioners in crop rotation and planting strategies to meet the competing objectives of objectives of sustainability and profitability. For example, many water intensive crops are in high demand, and thus highly profitable, while other crops with lower water requirements may have lower returns on investment. Thus, for a given farm, long term sustainability may be in direct competition with short term profitability. Our goal in this case would be to use MF-FMP2 within an objective function to assess the water requirements and

yields for crop distributions proposed by the optimizer. The objectives of this work are (1) to provide a framework so that MF-FMP simulations can be used with off-the-shelf optimization algorithms, (2) to understand the performance of evolutionary algorithms in comparison with other popular derivative-free methods, (3) develop intuitive ways to visualize and convey the results of the simulation and optimization to the end user (farmers).

**Carrie Rider** (joint work with Andrew Best, Andrea Ekey, Alyssa Everding, Sarah Jermeland, Jalen Marshall, Carrie Rider, Grace Silaban. Advisor: Dr. Heng Wang)
**Title:** *Protein-protein Interaction Detection Using Mixed Models*
**Abstract:** Membrane protein-protein interaction (PPI) plays an important role in biological processes; however, knowledge about membrane proteins is limited. Mating-based Split Ubiquitin System (mbSUS) is a technique used to investigate interactions between proteins by utilizing yeast as a heterologous system. The observed fluorescence scores are a result of PPI. We propose a statistic mixed model to improve the modeling of yeast growth, which provides a more accurate detection of the PPI. Our mixed model considers several factors that affect the observed fluorescence of the yeast, including test versus positive controls, variation due to individual plates, and PPI effects. The proposed model is applied to detect interactions between thousands of Arabidopsis membrane proteins. *This research project is supported by the National Science Foundation and the National Security Agency and is based on collaboration with Dr. Jin Chen, MSU-DOE Plant Research Laboratory, Computer Science and Engineering Department, Michigan State University

**Jeffrey Smith** (Advisor: Ming-Cheng Cheng)
**Title:** *A Physics-based Thermal Circuit Model for Multi-gate Field Effect Transistor Structures*
**Abstract:** The FinFET is a 3D transistor currently in development by the semiconductor industry. The non-planar geometry of the FinFET allows the device to overcome many short-channel effects present in conventional planar MOSFETs. Coupled with its high drive current and effective suppression of off-state leakage current, the FinFET shows significant potential in advancing CMOS technology past the 20nm node. However, the FinFET suffers from pronounced self-heating due to its SOI design, which may lead to degradation of performance and reliability of the device, thereby making an accurate thermal model indispensable to chip designers. A physics-based thermal-circuit model is proposed for the multi-fin FinFET that is capable of accounting for non-isothermal effects along the device channel and provides efficient implementation and accurate predictions. The proposed model makes use of characteristic thermal lengths to represent various paths of heat loss along each segment of the fins, channel and poly-wires and accounts for heat exchanges between neighboring fins or channels. The model is calibrated via 2D extraction of thermal resistances from finite element (FEM) simulations. The thermal-circuit will then be constructed in SPICE and the accuracy of the model will be tested against 3D numerical simulations of the multi-fin FinFET structure.

**Peter Vaillancourt** (Advisor: Joseph Skufca)
**Title:** *A Rigid Body Dynamics Model of a Pogo Stick*
**Abstract:** Previous studies of the dynamics of pogo sticks have been instrumental in the understanding of legged motion. These models utilized a simple point-mass system with a massless spring attached. However, a moment of inertia is necessary to model orientation control in the "flight" phase, so we formulate a rigid body model of a pogo stick and examine numerical solutions. Our model includes a system of two rigid bodies: the stick and the rider, which allows us to implement a control torque applied by the rider to produce "interesting" motions of the system. Where previous models have focused on the stability necessary for periodic forward hops, we focus on control during more complex rotations, such as forward and backward flips. The model is potentially generalizable to many spring-mass systems that undergo rotation, with applications to legged motion in robotics and prosthetics.

**Congzhi Xia** (Advisor: Guohui Song)
**Title:** *On the Merrifield-Simmons indices of bicyclic graphs*
**Abstract:** For a graph G, the Merrifield-Simmons index, i(G), is defined as the total number of the independent sets of the graph G. Let B(n) denote the set of bicyclic graphs on n vertices. H.Deng et al[J.Math. Chem. 43(1)(2008)75-91] obtained the maximal Merrifield-Simmons index of graphs in B(n) and determined the corresponding graph. In this paper, the second-, the third-, the fourth-, the fifth- and the sixth-maximal Merrifield-Simmons indices of bicyclic graphs in B(n) are characterized.

## Organizers
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### MCCNNY Organizing Committee
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