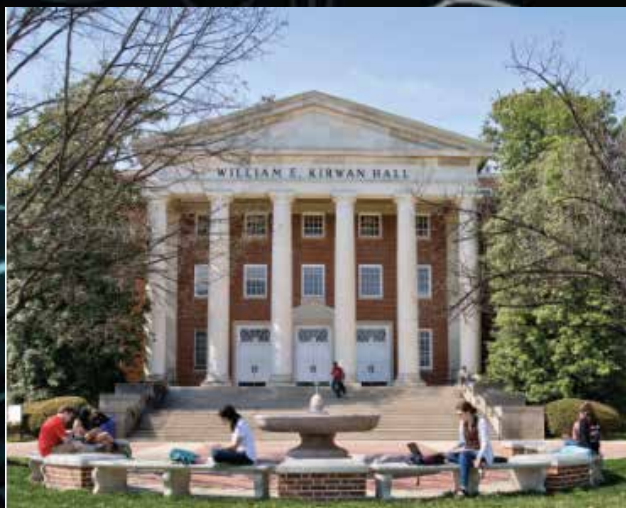




# Several Complex Variables, Complex Geometry and related PDEs

May 13-17, 2024



## About the Workshop

The main topics of the conference will be on Several Complex Variables, Complex Geometry and related PDEs. These areas have profound connections with many branches of mathematics such as partial differential equations, differential geometry, algebraic geometry, dynamics, and physics. It is expected that the workshop will lead to collaborations among mathematicians from several countries. It will also give graduate students and junior researchers the opportunity to meet leading experts in their areas of interest.

## Participants

John D'Angelo, University of Illinois, Urbana-Champaign  
 Shih-Kai Chiu, University of Oxford  
 Peter Ebenfelt, UC San Diego  
 Luke Edholm, The University of Vienna  
 Anne-Katrin Gallagher, Gallagher Tool & Instrument  
 Soumya Ganguly, UC San Diego  
 Xianghong Gong, University of Wisconsin-Madison  
 Xiaojun Huang, Rutgers University  
 Sharv Laad, UC San Diego  
 Laszlo Lempert, Purdue University  
 Chi Li, Rutgers University  
 Xiaoshan Li, Wuhan University  
 Stephanie Nivoche, Universite Cote d'Azur  
 Jian Song, Rutgers University  
 Laurent Stolovitch, Universite Cote d'Azur  
 Emil Straube, Texas A&M University  
 Song Sun, UC Berkeley  
 Valentino Tosatti, Courant Institute of Mathematical Sciences  
 Stefano Trapani, Universita Di Roma Tor Vergata  
 John Treuer, UC San Diego  
 Ming Xiao, UC San Diego  
 Weixia Zhu, University of Vienna  
 Andrew Zimmer, University of Wisconsin-Madison

## Organizers

Shiferaw Berhanu, University of Maryland  
 Tamas Darvas, University of Maryland  
 Bernhard Lamel, Texas A&M University at Qatar  
 Nordine Mir, Texas A&M University at Qatar





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# Schedule at a Glance

	Monday	Tuesday	Wednesday	Thursday	Friday
8:00					
9:00	Breakfast	Breakfast	Breakfast	Breakfast	Breakfast
10:00	Lempert	Xiao	Straube	Li	Zhu
11:00	Coffee Break	Coffee Break	Coffee Break	Coffee Break	Ganguly
	Trapani	Trusiani	D'Angelo	Nivoche	Coffee Break
12:00	Sun	Gallagher	Song	Li	Zimmer
13:00	Lunch	Lunch	Lunch on your own	Lunch	Stolovitch
14:00	Tosatti	Ebenfelt		Huang	Lunch on your own
15:00	Lin	Chiu		Gong	
16:00					
17:00					
18:00					

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# Workshop Overview

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The main topics of the conference will be on Several Complex Variables, Complex Geometry and related PDEs. These areas have profound connections with many branches of mathematics such as partial differential equations, differential geometry, algebraic geometry, dynamics, and physics. It is expected that the workshop will lead to collaborations among mathematicians from several countries. It will also give graduate students and junior researchers the opportunity to meet leading experts in their areas of interest.

## Organizing committee

SHIFERAW BERHANU, University of Maryland

TAMAS DARVAS, University of Maryland

BERNHARD LAMEL, Texas A& M and University at Qatar

NORDINE MIR, Texas A& M and University at Qatar

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# Workshop Schedule

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**MONDAY, MAY 13, 2024**

8:50 - 9:20      BREAKFAST

9:20 - 9:30      DORON LEVY (University of Maryland/Director, Brin MRC)  
*Opening*

9:30 - 10:20    LASZLO LEMPert (Purdue University)  
*A variational problem in Kähler geometry*

10:20 - 10:50   COFFEE BREAK

10:50 - 11:40   STEFANO TRAPANI (Universita Di Roma Tor Vergata)  
*Weakly Kahler hyperbolic space and Green-Griffith Lang Conjecture*

11:50 - 12:40   SONG SUN (University of California, Berkeley)  
*Complete Calabi-Yau metrics asymptotic to cones*

12:40 - 2:00    LUNCH

2:00 - 2:50      VALENTINO TOSATTI (Courant Institute of Mathematical Sciences)  
*Immortal solutions of the Kahler-Ricci flow*

3:00 - 3:50      YU-SHEN LIN (Boston University)  
*ALH\*-Gravitational Instantons*

## TUESDAY, MAY 14, 2024

9:00 - 9:30 BREAKFAST

9:30 - 10:20 MING XIAO (University of California, San Diego)  
*Kähler-Einstein Bergman metrics on pseudoconvex domains*

10:20 - 10:50 COFFEE BREAK

10:50 - 11:40 ANTONIO TRUSIANI (Chalmers University of Technology)  
*Singular cscK metrics on smoothable varieties*

11:50 - 12:40 ANNE-KATRIN GALLAGHER (Gallagher Tool & Instrument)  
*Equivalence between validity of the  $p$ -Poincaré inequality and finiteness of the strict  $p$ -capacitary inradius*

12:40 - 2:00 LUNCH

2:00 - 2:50 PETER EBENFELT (University of California, San Diego)  
*Bergman logarithmically flat and obstruction flat CR manifolds*

3:00 - 3:50 SHIH-KAI CHIU (Vanderbilt University)  
*Special Lagrangian submanifolds near adiabatic limits*

## WEDNESDAY, MAY 15, 2024

9:00 - 9:30 BREAKFAST

9:30 - 10:20 EMIL STRAUBE (Texas A&M University)  
*Sufficient conditions for global regularity in the  $\bar{\partial}$ -Neumann problem revisited*

10:20 - 10:50 COFFEE BREAK

10:50 - 11:40 JOHN D'ANGELO (University of Illinois, Urbana-Champaign)  
*Positivity Conditions in CR Geometry*

11:50 - 12:40 JIAN SONG (Rutgers University)  
*Geometric analysis on singular complex spaces*

12:40 - 2:00 LUNCH ON YOUR OWN

7:00 - 9:00 CONFERENCE DINNER



## THURSDAY, MAY 16, 2024

9:00 - 9:30 BREAKFAST

9:30 - 10:20 CHI LI (Rutgers University)  
*Kähler structures for holomorphic submersions*

10:20 - 10:50 COFFEE BREAK

10:50 - 11:40 STEPHANIE NIVOCHÉ (Université Côte d'Azur)  
*Pluricomplex Green's functions in connection with algebraic geometry problems*

11:50 - 12:40 XIAOSHAN LI (Wuhan University)  
*Semi-classical asymptotics of partial Bergman kernels on  $\mathbb{R}$ -symmetric complex manifolds with boundary*

12:40 - 2:00 LUNCH

2:00 - 2:50 XIAOJUN HUANG (Rutgers University)

3:00 - 3:50 XIANGHONG GONG (University of Wisconsin-Madison)  
*Global Newlander-Nirenberg problem on domains with finite smooth boundary in a complex manifold*

## FRIDAY, MAY 17, 2024

- 8:30 - 9:00      BREAKFAST
- 9:00 - 9:50      WEIXIA ZHU (University of Vienna)  
*Deformation of CR Structures and Spectral Stability of the Kohn Laplacian*
- 10:00 - 10:50    SOUMYA GANGULY (University of California, San Diego)  
*Locally algebraic Bergman kernels on two dimensional Stein spaces with finite type boundaries*
- 10:50 - 11:20    COFFEE BREAK
- 11:20 - 12:10    ANDREW ZIMMER (University of Wisconsin-Madison)  
*Smooth equivalence of families of strongly pseudoconvex domains*
- 12:20 - 1:10     LAURENT STOLOVITCH (Universite Cote d'Azur)  
*Local rigidity of actions of isometries on compact real analytic Riemannian manifolds*
- 1:10 - 3:00      LUNCH ON YOUR OWN

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# Abstracts of talks

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## A variational problem in Kähler geometry

LASZLO LEMPERT

*Purdue University*

Monday, May 13, 2024 @ 9:30 AM

Consider the following problem: Given a convex body in some real Euclidean space, among all ellipsoids inscribed in it find/characterize the one with greatest volume. This problem was posed and solved in a 1948 paper by Fritz John. A rather straightforward complex variant can be viewed as a question concerning hermitian metrics on line bundles over complex projective space. The talk will be about a certain generalization of this latter problem from projective spaces to general compact Kahler manifolds.

# Weakly Kahler hyperbolic space and Green-Griffith Lang Conjecture

STEFANO TRAPANI

*Universita Di Roma Tor Vergata*

Monday, May 13, 2024 @ 10:50 AM

I will talk about two papers one published one in preparation in collaboration with Benoit Claudon, Simone Diverio, Francesco Bei, and Philippe Eyssidieux In the early 90's Michail Gromov introduced the notion of Kahler hyperbolic manifolds, as a compact Kahler manifold whose pull back to the universal covering is exact with bounded potential. He proved this manifold have many interesting spectral and hyperbolicity properties. Few years later Janosh Kollar, on a book on Safarevich conjecture, asked if there were a more flexible notion of Kahler hyperbolicity invariant under bimeromorphic maps which would be suitable for complex and algebraic Geometry. In the first paper we introduce the notion of weakly hyperbolic manifold and prove several hyperbolic and spectral properties, in the second among other things we show biratioal invariance of this notion answering Kollar question.

## Complete Calabi-Yau metrics asymptotic to cones

SONG SUN

*University of California, Berkeley*

Monday, May 13, 2024 @ 11:50 AM

Complete Calabi-Yau metrics provide singularity models for limits of Kahler-Einstein metrics. We study complete Calabi-Yau metrics with Euclidean volume growth and quadratic curvature decay. It is known that under these assumptions the metric is always asymptotic to a unique cone at infinity. Previous work of Donaldson-Sun gives a 2-step degeneration to the cone in the algebro-geometric sense, via a possible intermediate object (a K-semistable cone). We will show that such intermediate K-semistable cone does not occur. This is in sharp contrast to the case of local singularities. This result together with the work of Conlon-Hein also give a complete algebro-geometric classification of these metrics, which in particular confirms Yau's compactification conjecture in this setting. I will explain the proof in this talk, and if time permits I will describe a conjectural picture in general when the curvature decay condition is removed. Based on joint work with Junsheng Zhang (UC Berkeley).

# Immortal solutions of the Kahler-Ricci flow

VALENTINO TOSATTI

*Courant Institute of Mathematical Sciences*

Monday, May 13, 2024 @ 2:00 PM

I will discuss the problem of understanding the long-time behavior of Ricci flow on a compact Kahler manifold, assuming that a solution exists for all positive time. Inspired by an analogy with the minimal model program in algebraic geometry, Song and Tian posed several conjectures which describe this behavior. I will report on recent work (joint with Hein and Lee) which confirms these conjectures.

# ALH\*-Gravitational Instantons

YU-SHEN LIN

*Boston University*

Monday, May 13, 2024 @ 3:00 PM

Gravitational instantons are introduced by Hawking as the building block of his Euclidean quantum gravity theory. Mathematically, they are non-compact hyperKähler manifolds with integrable curvature tensors and serve as non-compact analogue of K3 surfaces. They are divided into different types from their volume growth and curvature decay. In this talk, I will introduce the recent development of a certain type of gravitational instantons labeled by ALH\*. In particular, we will give a proof of the Torelli theorem and describe the moduli space of ALH\*-gravitational instantons. This talk is based on joint works with T. Collins, A. Jacob and T.-J Lee.

# Kahler-Einstein Bergman metrics on pseudoconvex domains

MING XIAO

*University of California, San Diego*

Tuesday, May 14, 2024 @ 9:30 AM

A well-known conjecture of Yau asserts that the Bergman metric on a bounded pseudoconvex domain in  $C^n$  is Kahler-Einstein if and only if the domain is homogeneous. A special case of this conjecture was posted earlier by Cheng: if the Bergman metric of a smoothly bounded strongly pseudoconvex domain is Kahler-Einstein, then the domain is biholomorphic to the unit ball. In this talk, we will discuss old and new results concerning the conjectures of Cheng and Yau.

# Singular cscK metrics on smoothable varieties

ANTONIO TRUSIANI

*Chalmers University of Technology*

Tuesday, May 14, 2024 @ 10:50 AM

We extend the notion of cscK metrics to singular varieties. We establish the existence of these canonical metrics on  $\mathbb{Q}$ -Gorenstein smoothable klt varieties when the Mabuchi functional is coercive, these arise as a limit of cscK metrics on close-by fibres. The proof relies on developing a novel strong topology of pluripotential theory in families and establishing uniform estimates for cscK metrics. A key point is the lower semicontinuity of the coercivity threshold of Mabuchi functional along degenerate families of normal compact Kähler varieties with klt singularities. The latter suggests the openness of (uniform) K-stability for general polarized families of normal projective varieties. This is a joint work with Chung-Ming Pan and Tat Dat Tô.

# Equivalence between validity of the $p$ -Poincaré inequality and finiteness of the strict $p$ -capacitary inradius

ANNE-KATRIN GALLAGHER

*Gallagher Tool & Instrument*

Tuesday, May 14, 2024 @ 11:50 AM

We will talk about the equivalence of the validity of the  $p$ -Poincaré inequality on an open set  $\Omega$  in  $\mathbb{R}^n$ , i.e.,

$$\|f\|_{p,\Omega} \leq C \|\nabla f\|_{p,\Omega} \quad \forall f \in C_c^\infty(\Omega)$$

for some  $C > 0$ , and the finiteness of the  $p$ -capacitary inradius,  $\rho_p(\Omega)$ , of  $\Omega$  defined by

$$\rho_p(\Omega) = \sup\{r > 0 : \forall \epsilon > 0 \exists x \in \mathbb{R}^n \text{ such that } C_p(\overline{\mathbb{B}_r(x)} \cap \Omega^c) < \epsilon\}$$

Here,  $C_p(E)$  denotes the Sobolev  $p$ -capacity of  $E$  for  $E \subset \mathbb{R}^n$ .

# Bergman logarithmically flat and obstruction flat CR manifolds

PETER EBENFELT

*University of California, San Diego*

Tuesday, May 14, 2024 @ 2:00 PM

Let  $\Omega \subset \mathbb{C}^n$  be a smoothly bounded, strictly pseudoconvex domain. The boundary  $\partial\Omega$  is said to be *Bergman logarithmically flat* if the log singularity in Fefferman's asymptotic expansion of the Bergman kernel vanishes (to infinite order). It is called *obstruction flat* if the log singularity (the obstruction function) of the Cheng–Yau log-potential of the complete Kähler-Einstein metric in  $\Omega$  vanishes. The Ramadanov Conjecture asserts that if  $\partial\Omega$  is Bergman logarithmically flat, then it is spherical. There is a similar conjecture for obstruction flat boundaries. Both conjectures, suitably reformulated, fail for domains in more general complex manifolds in higher dimension ( $n \geq 3$ ), but the situation is still unclear for domains in  $\mathbb{C}^n$  (for  $n \geq 3$ ). In this talk, we shall survey recent work and open questions concerning these conjectures and the general structure of Bergman logarithmically flat and obstruction flat CR manifolds.

# Special Lagrangian submanifolds near adiabatic limits

SHIH-KAI CHIU

*Vanderbilt University*

Tuesday, May 14, 2024 @ 3:00 PM

Finding special Lagrangian submanifolds in compact Calabi-Yau manifolds is an important problem in complex geometry. In this talk, we discuss a new gluing construction of special Lagrangian submanifolds in compact Calabi-Yau 3-folds admitting Lefschetz K3 fibrations. When the Calabi-Yau metric is sufficiently collapsed, we show that certain 1-dimensional graphs in the base correspond to special Lagrangian submanifolds. Joint work with Yu-Shen Lin.

# Sufficient conditions for global regularity in the $\bar{\partial}$ -Neumann problem revisited

EMIL STRAUBE

*Texas A&M University*

Wednesday, May 15, 2024 @ 9:30 AM

I will give a general sufficient condition for global regularity in the  $\bar{\partial}$ -Neumann problem for smooth bounded pseudoconvex domains in  $\mathbb{C}^n$  with comparable Levi eigenvalues. The condition is a significant improvement over one I proved in 2008 (for general pseudoconvex domains). For domains in  $\mathbb{C}^2$ , the condition covers (essentially?) all known sufficient conditions. This is a report on work in progress.



# Positivity Conditions in CR Geometry

JOHN D'ANGELO

*University of Illinois, Urbana-Champaign*

Wednesday, May 15, 2024 @ 10:50 AM

After recalling the Riesz-Fejer Theorem from 1916, I will discuss various similar questions in higher dimensions and their relationships to CR Geometry.

# Geometric analysis on singular complex spaces

JIAN SONG

*Rutgers University*

Wednesday, May 15, 2024 @ 11:50 AM

We establish a uniform Sobolev inequality and diameter bound for Kahler metrics, which only require an entropy bound and no lower bound on the Ricci curvature. We further extend our Sobolev inequality to singular Kahler metrics on Kahler spaces with normal singularities. This allows us to build a general theory of global geometric analysis on singular Kahler spaces including the spectral theorem, heat kernel estimates, eigenvalue estimates and diameter estimates. Such estimates were only known previously in very special cases such as Bergman metrics. As a consequence, we derive various geometric estimates, such as the diameter estimate and the Sobolev inequality, for Kahler-Einstein currents on projective varieties with definite or vanishing first Chern class.

# Kahler structures for holomorphic submersions

CHI LI

*Rutgers University*

Thursday, May 16, 2024 @ 9:30 AM

We prove a criterion for the existence of Kahler structure for any holomorphic submersion. This criterion generalizes Blanchard's criterion for isotrivial holomorphic submersions. We then discuss its application to a question of Harvey-Lawson in the case of fiber dimension one and to the existence of Hermitian-Symplectic structures.

# Pluricomplex Green's functions in connection with algebraic geometry problems

STEPHANIE NIVOCHÉ

*Universite Cote d'Azur*

Thursday, May 16, 2024 @ 10:50 AM

The Nagata Conjecture governs the minimal degree required for a plane algebraic curve to pass through a collection of  $r$  general points in the projective plane  $\mathbb{P}^2$  with prescribed multiplicities. The "SHGH" Conjecture governs the dimension of the linear space of these polynomials. We formulate transcendental versions of these conjectures in term of pluripotential theory and we're making some progress.

# Semi-classical asymptotics of partial Bergman kernels on $\mathbb{R}$ -symmetric complex manifolds with boundary

XIAOSHAN LI

*Wuhan University*

Thursday, May 16, 2024 @ 11:50 AM

In this talk, we will talk about an asymptotic expansion of a partial Bergman kernel and its applications on a  $\mathbb{R}$ -symmetric complex manifold with smooth boundary. Let  $M$  be a relatively compact connected open subset with smooth connected boundary of a complex manifold  $M'$ . Let  $(L, h^L) \rightarrow M'$  be a positive line bundle over  $M'$ . Suppose that  $M'$  admits a holomorphic  $\mathbb{R}$ -action which preserves the boundary of  $M$  and lifts to  $L$ . We will show an asymptotic expansion of a partial Bergman kernel associated to a package of Fourier modes of high frequency with respect to the  $\mathbb{R}$ -action in the high powers of  $L$ . As an application, we establish an  $\mathbb{R}$ -equivariant analogue of Fefferman's and Bell-Ligocka's result about smooth extension up to the boundary of biholomorphic maps between weakly pseudoconvex domains in  $\mathbb{C}^n$ . Another application concerns the embedding of pseudoconcave manifolds.

**TBD**

XIAOJUN HUANG

*Rutgers University*

Thursday, May 16, 2024 @ 2:00 PM

# Global Newlander-Nirenberg problem on domains with finite smooth boundary in a complex manifold

XIANGHONG GONG

*University of Wisconsin-Madison*

Thursday, May 16, 2024 @ 3:00 PM

Let  $M$  be a relatively compact  $C^2$  domain in a complex manifold  $X$  of dimension  $n$ . Assume that  $H_{\bar{\partial}}^{(0,1)}(M, \Theta) = 0$  where  $\Theta$  is the holomorphic tangent bundle of  $M$ . Suppose that the Levi-form of the boundary of  $M$  has at least 3 negative eigenvalues or at least  $n - 1$  positive eigenvalues pointwise. We will first construct a homotopy formula for  $\Theta$ -valued  $(0, 1)$ -forms on  $\bar{M}$ . We then apply a modified Nash-Moser iteration scheme to show that when a formally integrable and smooth almost complex structure on  $\bar{M}$  is sufficiently close to the complex structure on  $\bar{M}$ , there is a smooth diffeomorphism  $F$  from  $\bar{M}$  into  $X$  transforming the almost complex structure into the complex structure on  $F(M)$ . We will also present results when the formally integral almost complex structure and the boundary of  $M$  are finite smooth. This is joint work with Ziming Shi.

# Deformation of CR Structures and Spectral Stability of the Kohn Laplacian

WEIXIA ZHU

*University of Vienna*

Friday, May 17, 2024 @ 9:00 AM

The interplay between deformation of complex structures and stability of the spectrum for the complex Laplacian on compact complex manifolds was extensively studied by Kodaira and Spencer in the 1950s. In this talk, we will discuss analogous problems for compact CR manifolds, focusing on the relationship between spectral stability and embedding stability for 3-dimensional pseudoconvex CR manifolds of finite type. This talk is based on joint work with Siqi Fu and Howard Jacobowitz.

# Locally algebraic Bergman kernels on two dimensional Stein spaces with finite type boundaries

SOUMYA GANGULY

*University of California, San Diego*

Friday, May 17, 2024 @ 10:00 AM

On a two dimensional Stein space with isolated, normal singularities, finite type boundary and locally algebraic Bergman kernel, we find an estimate of the local algebraic degree of the Bergman kernel in terms of the type of the boundary. As an application, we characterize two dimensional ball quotients as finite type Stein spaces with rational Bergman kernel. It is a joint work with P. Ebenfelt, and M. Xiao

# Smooth equivalence of families of strongly pseudoconvex domains

ANDREW ZIMMER

*University of Wisconsin-Madison*

Friday, May 17, 2024 @ 11:20 AM

In talk I will discuss regularity results for families of biholomorphisms between smooth families of strongly pseudoconvex domains. This is joint work with H. Gaussier and X. Gong.

# Local rigidity of actions of isometries on compact real analytic Riemannian manifolds

LAURENT STOLOVITCH

*Universite Cote d'Azur*

Friday, May 17, 2024 @ 12:20 PM

In this work in collaboration with Z. Zhao (Nice), we consider analytic perturbations of isometries of an analytic Riemannian manifold  $M$ . We prove that, under some conditions, a finitely presented group of such small enough perturbations is analytically conjugate on  $M$  to the same group of isometry it is a perturbation of. Our result relies on a "Diophantine-like" condition, relating the actions of the isometry group and the eigenvalues of the Laplace-Beltrami operator. Our result generalizes Arnold-Herman's theorem about diffeomorphisms of the circle that are small perturbations of rotations.

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# The Brin Mathematics Research Center

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The Brin Mathematics Research Center is a research center that sponsors activity in all areas of pure and applied mathematics and statistics. The Brin MRC was funded in 2022 through a generous gift from the Brin Family. The Brin MRC is part of the Department of Mathematics at the University of Maryland, College Park.

Activities sponsored by the Brin MRC include long programs, conferences and workshops, special lecture series, and summer schools. The Brin MRC provides ample opportunities for short-term and long-term visitors that are interested in interacting with the faculty at the University of Maryland and in experiencing the metropolitan Washington DC area.

The mission of the Brin MRC is to promote excellence in mathematical sciences. The Brin MRC is home to educational and research activities in all areas of mathematics. The Brin MRC provides opportunities to the global mathematical community to interact with researchers at the University of Maryland. The center allows the University of Maryland to expand and showcase its mathematics and statistics research excellence nationally and internationally.

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# List of Participants

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SHIFERAW BERHANU, University of Maryland  
SHIH-KAI CHIU, Vanderbilt University  
JOHN D'ANGELO, University of Illinois, Urbana-Champaign  
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PRAKHAR GUPTA, University of Maryland  
YU-CHI HOU, University of Maryland  
XIAOJUN HUANG, Rutgers University  
CHENZI JIN, University of Maryland  
SZE HONG KWONG, University of Maryland  
SHARV LAAD, University of California, San Diego  
LASZLO LEMPert, Purdue University  
DORON LEVY, University of Maryland/Director, Brin MRC  
XIAOSHAN LI, Wuhan University  
CHI LI , Rutgers University  
YU-SHEN LIN, Boston University  
YAXIONG LIU, University of Maryland  
VLASIOS MASTRANTONIS, University of Maryland  
DUC NGUYEN, University of Maryland  
STEPHANIE NIVOCHÉ, Université Côte d'Azur  
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JIAN SONG, Rutgers University  
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JOHN TREUER, The University of California at San Diego  
ANTONIO TRUSIANI, Chalmers University of Technology  
MING XIAO, University of California, San Diego



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