

RTG Activities (2023-2024)

Organization

Meetings

The RTG PIs and Senior Personnel met every 3 weeks. These meetings were organized by Jason Metcalfe (PI). The agenda for each meeting was shared in advance and the overall goal was to discuss the progress of the ongoing RTG activities, as well as plan future ones. These meetings guarantee that the RTG goals are met by promoting that the group acts in a cohesive and efficient manner.

Website

As planned, the RTG developed a website for disseminating its activities and results. The website URL is <https://tarheels.live/waves/>. It is updated weekly with information on ongoing activities and news.

Dissemination

Local activities are advertised via departmental email and are posted on a hallway board that is exclusively dedicated to displaying RTG activities. To advertise activities that are designed to reach a wider audience of students and faculty outside UNC-Chapel Hill, the RTG created an email list of about 150 faculty colleagues who work across the globe. Posters are created for each of these activities, and they are shared via email and posted on the RTG website. The posters can be found enclosed in the supporting pdf documents.

Participants and Mentoring

Participants

The RTG **postdocs** for the second year of the RTG were:

- Jian Wang. Mentors: Hans Christianson(co-PI) and Jeremy Marzuola (co-PI)
- Daniel Weser. Mentors: Arunima Bhattacharya (Senior Personnel) and Jeremy Marzuola (co-PI)
- James Rowan. Mentors: Jeremy Marzuola (co-PI) and Casey Rodriguez (co-PI)

The RTG **graduate researchers** for the second year of the RTG were:

- Andy Badea. Expected graduation: Spring 2028. Temporary mentor: Hans Christianson (co-PI)
- Corbin Balitactac. Expected graduation: Spring 2027. Mentor: Casey Rodriguez (co-PI)
- Benjamin Bechtold. Expected graduation: Spring 2025. Mentor: Jason Metcalfe (PI)
- Madelyne Brown. Graduation: Spring 2024. Mentor: Yaiza Canzani (co-PI)
- Sarah Carpenter. Expected graduation: Fall 2024. Mentor: Hans Christianson(co-PI)
- Tim Van Hoose. Expected graduation: Spring 2027. Mentor: Jeremy Marzuola (co-PI)
- Andrew Lyons. Expected graduation: Spring 2026. Mentors: Yaiza Canzani (co-PI) and Jeremy Marzuola (co-PI)
- Connor Menzel. Expected graduation: Spring 2028. Temporary mentor: Hans Christianson(co-PI)
- Jeremy Wall. Expected graduation: Spring 2026. Mentor: Arunima Bhattacharya (Senior Personnel)

The RTG **undergraduate researchers** for the second year of the RTG were:

- Maria Tyurina. Graduated: December 2023. Mentor: Casey Rodriguez (co-PI).
- Marvin Koonce. Expected graduation: Spring 2025. Mentor: Jason Metcalfe (PI)
- Marleigh Purgar-McDonald. Graduation: Spring 2024. Mentor: Hans Christianson (co-PI)
- Chloe Shen. Expected graduation: Spring 2025. Mentor: Jason Metcalfe (PI)
- Joe Stellman. Expected graduation: Spring 2025. Mentor: Jeremy Marzuola (co-PI)
- Henry Woodburn. Expected graduation: Spring 2025. Mentor: Jeremy Marzuola (co-PI) and Madelyne Brown (RTG graduate student)

The RTG **high school researchers** for the second year of the RTG were:

- Paul Rosu. Mentor: Jeremy Marzuola (co-PI)

Mentoring

As planned, every term, each of the RTG postdocs and students went through a review of their Individual Development Plans (IDPs) and their dossier. These meetings took place with the mentor assigned to each participant and a second faculty member from the RTG grant.

The IDPs were created by Jason Metcalfe (PI) and are available to the public in the RTG website under “Scrolls”. The meetings were organized by Jason Metcalfe (PI) and Yaiza Canzani (co-PI).

Incoming Postdoctoral Associates

The RTG hired its second cohort of RTG Postdoctoral Associates. The search committee consisted of Arunima Bhattacharya (Senior Personnel), Yaiza Canzani (co-PI), Hans Christianson (co-PI), Jeremy Marzuola (co-PI), and Casey Rodriguez (co-PI).

The RTG hired Hanna Kim (University of Illinois at Urbana Champaign) and Giovanni Granados (Purdue University), who will join the RTG activities on July 1, 2024. They were among the top three candidates in the short list for the job search. The job ad had a total of 90 applicants.

Past Participants Placement:

Graduate Students:

- Madelyne Brown, who worked with Yaiza Canzani (co-PI), will be a Postdoctoral Fellow at The University of Auckland for the 2024-2025 AY. She will then be an Assistant Professor of Mathematics at Oberlin College & Conservatory.
- Derrick Nowack: Plans to work in industry.

Undergraduate Students:

- Ameer Qaquish, who worked with Hans Christianson (co-PI), joined the Biostatistics graduate program at UNC.
- David Snider, who worked with Mark Williams (Senior Personnel), defended his honors thesis “Nonlinear geometric optics for pulses with nonlinear phases”. He is now enrolled in the graduate program in statistics at Columbia University.

- Xiao-Ming Porter graduated, who worked with Jason Metcalfe (PI), with honors with a thesis titled “Local energy estimates for damped waves”. Xiao-Ming enrolled in the graduate program in mathematics at the National University of Singapore.
- Yizhou Gu, who worked with Jason Metcalfe (PI), enrolled at the University of Michigan in statistics. She was one of the 2023 recipients of the Archibald Henderson Mathematics Medal and received recognition at the 2023 Chancellor’s Awards Ceremony.
- Marleigh Purgar-McDonald, who worked with Hans Christianson (co-PI), graduated in 2024 and will enroll in the doctoral program in mathematics at Texas A&M University.

High school students:

- Liam Buttita, who worked with Casey Rodriguez (co-PI), enrolled in the Undergraduate Program at University of Illinois Urbana-Champaign.
- Zubin Narayan, who worked with Jason Metcalfe (PI) and Ben Bechtold (RTG graduate student), enrolled in the Undergraduate Program at Carnegie Mellon University.

Proposed Activities

Developmental training groups

During the Fall 2023, the RTG ran the second year of the Developmental Training Group, designed and led by Yaiza Canzani (co-PI).

- The main activity consisted of weekly 2.5-hours meetings from August 25 to October 6, 2023, during which the participants designed and developed their materials to apply for an NSF GRFP. The materials included a CV, a research statement, and a personal statement. The program had 8 graduate student participants from all areas of mathematics, including 3 female students. Throughout the workshop, the students received feedback on their work from both peers and faculty. This led to three applications for the NSF GRFP being submitted. The small number of submissions is due to students struggling to find a faculty advisor willing to act as a mentor. We plan to mitigate this in the future by helping the students more closely during that part of the process.
- The RTG organized a “Thinking of Doing a Ph.D. in Math?” panel. This was an informal meet-up where undergraduate students thinking of pursuing a doctorate degree in mathematics could meet with faculty and ask questions. The activity was run as part of University Research Week. The faculty were Yaiza Canzani (co-PI), Jason Metcalfe (PI), Casey Rodriguez (co-PI), Daniel Weser (RTG Postdoc). The meeting took place on October 26, 2023 and there were 7 undergraduate student participants.

Mini-Schools

The RTG ran its second PDE mini-school “Recent developments in wave turbulence theory” on April 5-6, 2024. The school was organized by Yaiza Canzani (co-PI), Casey Rodriguez (co-PI), and James Rowan (RTG Postdoc).

- The mini-school consisted of four main lectures taught by Gigliola Staffilani (MIT) together with three satellite talks given by Gonzalo Cao-Labora (MIT), Felipe Hernandez (MIT), and Xueying Yu (Oregon State University).

- There were a total number of 40 participants, including graduate students, postdocs, and faculty. The program funded 11 graduate students and 2 postdocs from 10 peer universities across the US. The RTG covered their lodging and transportation expenses. Ten of the funded participants were US Citizens or permanent residents. Four of the funded participants identified as female. The funded applicants were asked to submit a CV, a statement of purpose, and a letter of recommendation by their mentor.
- The mini-school had a reception dinner and three coffee breaks in between the talks and lectures to allow the participants to socialize and ask questions. The recorded lectures were added as materials to the RTG “Online Topics Course Collaborative”. The school was advertised via email and a poster was created for this purpose.
- The participants were surveyed after the event ended. They conveyed appreciation for the mini-school and expressed that they would like to participate in future events that the RTG may hold as well as apply for postdocs and professorship positions that the Analysis and PDE group at UNC may advertise.

Research Playground

The second year of the Research Playground was designed and run by Hans Christianson (co-PI) and Department Postdoctoral Associate Jian Wang.

- During the Fall term of 2023, the activity gathered 4 junior graduate students interested in this research-based learning experience. The topic was “Observability for the wave equation on triangles”. The students and faculty met once a week for a 1-2 hour period. The students learned and presented material, mainly following the paper “Asymptotic Boundary Observability for the Wave Equation From One Side of a Planar Triangle” by H. Christianson and E. Stafford. This was supplemented by notes and presentations on control theory from Christianson and Wang, as well as a presentation on the system of linear elasticity from Casey Rodriguez (co-PI).
- Once the term ended the students were surveyed and 3 of them expressed interest in starting a research project related to the material that they had learned. In addition, one also expressed interest in studying observability for the heat equation in this context.
- During the Spring term of 2024, 3 first year students continued in the Research Playground. Students and faculty met once a week for a 1-2 hour period. They started research on observability for solutions to the linear elasticity system. This project will likely result in a publication.

Undergraduate Research Seminar

During the Fall 2023 and Spring 2024 terms, the Undergraduate Research Seminar met on a monthly basis over Zoom. The organizers were Casey Rodriguez (co-PI), Jeremy Marzuola (co-PI), and James Rowan (RTG Postdoc).

- The attendance for each event averaged between 30 and 70 participants. The seminar was advertised via email, and a poster for each event was created for this purpose.
- Each gathering consisted of two invited talks; one by an undergraduate student who is working on a research project, and one by a faculty member or graduate student who is supervising undergraduate research. The invited leading faculty or graduate speakers were Shadi-Tahvildar Zadeh (Rutgers), Peter McGrath (NCSU), Stefan Steinerberger (UW), Alex Ortiz (MIT), Kelly Bickel

(Bucknell University), Tom Beck (Fordham University), and Jeremy Marzuola (UNC). Abstracts and schedules for the talks were regularly posted in the RTG website.

Asynchronous graduate courses

During Spring 2024, a graduate course on Spectral Theory was developed and taught by Casey Rodriguez (co-PI). This course is one of the three second-tier asynchronous courses proposed by the RTG with the goal that a broader selection of courses could be offered every year, without overtaxing the available faculty and teaching resources of the UNC Mathematics department. As planned, the course was first offered in a traditional format and was recorded for future online availability.

Online Topics Course Collaborative

This RTG activity is led by Hans Christianson (co-PI). The website for the Collaborative is being created and institutions participating in the Collaborative will be contacted in Summer 2024 to begin the course sharing. All the main lectures taught under the scope of this RTG have been recorded.

Analysis and PDE seminar

During the Fall 2023 and Spring 2024 terms, the M. E. Taylor Analysis and PDE Seminar hosted a total of 16 speakers from institutions across the world. The organizers were Casey Rodriguez (co-PI), Arunima Bhattacharya (Senior Personnel), and Dan Weser (RTG Postdoc). On a weekly basis, the Seminar gathered about 18 participants including a constant cohort of 10 graduate students. The speakers were: Kiril Datchev (Purdue), Melanie Graf (University of Hamburg), Anna Skorobogatova (Princeton), Rita Teixeira da Costa (Princeton, Trinity College), Ruoyu P. T. Wang (University College London), Benjamin Harrop-Griffiths (Georgetown), Jian Wang (UNC), Anna Zemlyanova (KSU), Peter McGrath (NCSU), Maja Taskovic (Emory University), Boya Liu (NCSU), Zane Li (NCSU), Saman Habibi Esfahani (Duke), Lizhe Wan (UW-Madison), Jeremy Wall (UNC), and Micah Warren (UOregon). The schedules and abstracts for the talks were regularly posted on the RTG website. In addition, the Seminar and the graduate AWM chapter jointly hosted informal Q&A lunches with speakers: Anna Skorobogatova (Princeton), Anna Zemlyanova (KSU), and Maja Taskovic (Emory University).

Special colloquiums and Events

- Colloquium: K. R. Rajagopal (Texas A&M University) delivered a talk on “The mathematics and mechanics of bodies described by implicit constitutive equations” on September 7, 2023. The event had about 60 participants and was hosted by Casey Rodriguez (co-PI).
- Colloquium: S. Tahvildor-Zadeh (Rutgers University) delivered a talk on “Spectral lines of general relativistic hydrogen” on March 7, 2023. The event had about 50 participants and was hosted by Casey Rodriguez (co-PI).

Research activities

Talks

Talks by faculty

- Arunima Bhattacharya (Senior Personnel)

- European Congress of Mathematicians: Satellite Conference on Analysis and PDE, Portugal (July 2024)
 - Partial Differential Equations and Convexity, (special session of AMS sectional meeting), San Francisco (May 2024)
 - PDEs in Complex Geometry: Thematic program, Centre de Recherches Mathématiques (CRM), Montréal, Canada, (April 2024)
 - PDE seminar, Indiana University (Spring, 2024)
 - Geometric Analysis Colloquium, Fields Institute, Toronto, Canada (February, 2024)
 - Geometry-Topology seminar, North Carolina State University (August 25, 2023)
 - Colloquium, Tata Institute of Fundamental Research, Mumbai, India (August 3, 2023)
 - Geometric Analysis Seminar, University of Oregon (May 16, 2023)
- Yaiza Canzani (co-PI)
 - 13th Ohio River Analysis Meeting (March 16-17, 2024)
 - 8th Coloquio Uruguayo de Matematica (December 19-21, 2023)
- Jeremy Marzuola (co-PI)
 - Georgia Tech PDE Seminar (March 12, 2024)
 - Berkeley PDE Seminar (March 15, 2024)
 - George Mason University Applied & Computational Mathematics Seminar (September 29, 2023)
 - ESI Program on Spectral Theory and Mathematical Relativity, Vienna, June 5-July 28, 2023
- Casey Rodriguez (co-PI)
 - PDE Seminar, Georgia Tech (March 26, 2024)
 - Great Lakes Mathematical Physics Meeting (GLaMP), Michigan State University (June 7-9, 2024)
 - Colloquium, Virginia Tech (December 1, 2023)

Talks by Postdocs

- James Rowan:
 - MSRI program Mathematical Problems in Fluid Dynamics, part 2.
- Jian Wang:
 - Colloquium, the University of Melbourne (February 6, 2024)
 - Colloquium, Texas A&M University (January 25, 2024)
 - Colloquium, the University of Pittsburgh (January 23, 2024)
 - PDE Seminar, Laboratoire de Mathématiques d'Orsay (November 23, 2023)

- Microlocal Analysis Seminar (online), Tsinghua University and Fudan University (November 14, 2023)
- M. E. Taylor Analysis and PDE Seminar, UNC (November 1, 2023)
- Mini-course: The mathematics of internal wave attractors, Tsinghua University (June 2023)
- Spectral Geometry Seminar, University of Science and Technology of China (July 7, 2023)

Talks by Graduate Students

- Benjamin Bechtold
 - Spring 2024 TAGMaC at UNC
- Maddie Brown
 - Fall 2023 TAGMaC at NCSU, Spring 2024 TAGMaC at UNC
- Andrew Lyons
 - Fall 2023 TAGMaC at NCSU, Spring 2024 TAGMaC at UNC
- Timothy Van Hoose
 - Spring 2024 TAGMaC at UNC
- Jeremy Wall
 - Fall 2023 TAGMaC at NCSU, Spring 2024 TAGMaC at UNC
 - M.E. Taylor Analysis and PDE Seminar (April 17, 2024)

Talks by Undergraduate Students

- Xiao-Ming Porter presented their research at the 2023 UNC Celebration of Undergraduate Research.
- Yizhou Gu presented their research at the 2023 UNC Celebration of Undergraduate Research.

Research

Articles by faculty

- Arunima Bhattacharya (Senior Personnel)
 - J. Bernstein and A. Bhattacharya, Minimal surfaces and Colding-Minicozzi Entropy in the Complex Hyperbolic Space. arXiv:2307.08128
 - Bhattacharya and A. Skorobogatova, Variational integrals on Hessian spaces: partial regularity for critical points. arXiv:2006.02030
 - A. Bhattacharya and R. Shankar, Regularity for convex viscosity solutions of Lagrangian mean curvature equation, Crelle's Journal, to appear.
- Yaiza Canzani (co-PI)
 - Y. Canzani and J. Galkowski: Geodesic Beams in Eigenfunction Analysis. Synthesis Lectures on Mathematics & Statistics. Springer Nature. (2023)
- Hans Christianson (co-PI)

- H. Christianson and J. Toth, Small-scale mass estimates for Neumann eigenfunctions: piecewise smooth planar domains. arXiv:2309.10875
- H. Christianson and J. Toth, Quantum Flux and Quantum Ergodicity for Cross Sections. arXiv:2404.02296
- Jeremy Marzuola (co-PI)
 - Roy H. Goodman, Grace Conte, and Jeremy L. Marzuola QGLab: A MatLab Package for Computations on Quantum Graphs
 - Kiril Datchev, Jeremy L. Marzuola and Jared Wunsch, Newton polygons and resonances of multiple delta-potentials. Trans. Amer. Math. Soc., to appear.
 - Zachary M. Boyd, Nicolas Fraiman, Jeremy L. Marzuola, Peter J. Mucha, and Braxton Osting, Escape times for subgraph detection and graph partitioning. SIAM J. Matrix Anal., to appear.
 - T. Alazard, J. L. Marzuola, and J. Wang: Damping for fractional wave equations and applications to water waves. arXiv:2308.09288
- Casey Rodriguez (co-PI)
 - C. Rodriguez, A midsurface elasticity model for a thin, nonlinear gradient elastic plate. Int. J. Eng. Sci. 197 (2014) 104026, 17pp.
 - K. R. Rajagopal and C. Rodriguez: Special Cosserat rods with rate-dependent evolving natural configurations. Int. J. Eng. Sci., 191 (2023), 103890, 19pp.
- Mark Williams (Senior Personnel)
 - J. Wang and M. Williams: Transport of nonlinear oscillations along rays that graze a convex obstacle to any order. arXiv:2309.05910

Articles by Postdocs

- Jian Wang
 - J. Wang and M. Williams: Transport of nonlinear oscillations along rays that graze a convex obstacle to any order. arXiv:2309.05910
 - H. Christianson, J. Wang, and R. P. T. Wang, Control estimates for 0th-order pseudodifferential operators, International Mathematics Research Notices, published online.
 - S. Dyatlov, J. Wang, and M. Zworski, Mathematics of internal waves in a 2D aquarium, to appear in Analysis & PDE.
 - T. Alazard, J. L. Marzuola, and J. Wang: Damping for fractional wave equations and applications to water waves. arXiv:2308.09288

Articles by Graduate Students

- T. Van Hoose:
 - Modified Scattering for the Schrödinger-Bopp-Podolsky equation. arXiv:2306.12561
- Andrew Lyons:

- A. Lyons: Nodal sets of Laplacian Eigenfunctions with an eigenvalue of multiplicity 2. arXiv:2312.05369
- Jeremy Wall:
 - A. Bhattacharya and J. Wall: Hessian estimates for shrinkers, expanders, translators, and rotators of the Lagrangian Mean Curvature Flow. arXiv: 2403.07235

New grants:

- The Simons Foundation will support Arunima Battacharya (Senior Personnel) through a Travel Support for Mathematicians grant. The project is titled “Nonlinear PDEs in Lagrangian Geometry” and will run 9/1/2023-8/31/2028.
- The National Science Foundation will support Jeremy Marzuola (co-PI) through the grant “Spectral theory and applications for models with localized or boundary defects” from 7/2023-6/2026.
- The National Science Foundation will support Casey Rodriguez (co-PI) through the grant “Collaborative Research: Strain-limiting Cosserat Rods with Applications to Modeling Biological Fibers” for the period 8/1/2023-7/31/2026.

Outreach

- Girls Talk Math: The RTG partially supported the “Girls Talk Math” program on Summer 2023. This is a free educational summer program that strives to make advanced mathematics accessible to students of underrepresented genders in STEM. Its founders, Katrina Morgan and Francesca Bernardi, are former UNC graduate students.

Miscellaneous News

- Yaiza Canzani (co-PI) and her co-author Jeff Galkowski on the publication of their new book: *Geodesic beams in eigenfunction analysis*.
- Jason Metcalfe (PI) was appointed Chair of the Department of Mathematics
- Arunima Bhattacharya (Senior Personnel) was featured in the Community Spotlight from MSRI / the Simons Lauer Mathematical Sciences Institute.
- Yaiza Canzani (co-PI) was awarded by UNC the Phillip and Ruth Hettleman Prizes for Artistic and Scholarly Achievement.
- Casey Rodriguez (co-PI) was awarded the Goodman-Petersen Award for Excellence in Undergraduate Education by the Mathematics Department at UNC.