MSRI
Mathematical Sciences Research Institute

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Final Report on the Mathematical Sciences Research Institute 2021-22 Activities supported by NSA Grant H98230-21-1-0060 Support of Early Career Researchers at MSRI 6/15/21- 6/14/22

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Mathematical Sciences Research Institute
NSA Final Report for H98230-21-1-0060

I. INTRODUCTION

The main scientific activities of MSRI are its programs and workshops. MSRI hosts two to four semester-long programs each year. Each program has about forty mathematicians in residence at any given time, including seven to eight graduate students. On average, there are 70 to 80 total members in residence over the course of the semester including about 15 graduate students.

Generally, each semester-long program features three workshops. A program begins with a *Connections Workshop*, which has three overarching goals: (1) to give accessible introductions to the main themes of the program and exciting new directions in related research; (2) to provide participants the opportunity to become acquainted with the work of women in the field; and (3) to connect early-career researchers, especially women, gender-expansive individuals, and minorities, to potential senior mentors. This workshop is then followed by an *Introductory Workshop*, the purpose of which is to introduce the subject to the broader mathematical community. Later during the program, there is a *Topical Workshop*, which is designed to explore some of the themes of the program in greater depth.

In addition to the scientific workshops that run parallel with the programs, MSRI hosts one or two Hot Topics workshops. These workshops are intended to explore emerging topics in mathematics. (See Section II.B for a brief summary)

MSRI also hosts and co-hosts many other workshop series and shorter programs, which are described in detail on our website at https://www.msri.org/web/msri/scientific. This report covers only the events listed above, which are the primary activities in which MSRI's postdoctoral fellows participate.

II. OVERVIEW OF ACTIVITIES 2021-22

The year 2021-22 was an exciting one. In the fall semester (from August 16 to December 17, 2021) MSRI held the jumbo program *Universality and Integrability in Random Matrix Theory and Interacting Particle Systems*, led by Ivan Corwin (Columbia University). In the spring semester (from January 18 to May 27, 2022) we held two programs: *The Analysis and Geometry of Random Spaces*, led by Mario Bonk (University of California, Los Angeles) and *Complex Dynamics: From Special Families to Natural Generalizations in one and Several Variables*, led by Sarah Koch (University of Michigan). MSRI also hosted a small Complementary Program for mathematicians whose interests were closely related to the research area of the directorate. Due to the COVID-19 pandemic, in-person attendance at MSRI's workshops was restricted to program members already in residence and

invited workshop speakers/organizers. The workshops were open to online attendees worldwide. The three 2021-22 programs are briefly summarized below.

There were 204 researchers who were in residence at MSRI for the 2021-22 programs. Of those members, there were 29 Postdoctoral Fellows, 60 Organizers & Research Professors, 77 Research Members, and 31 Program Associates (Graduate Students).

The NSA grant H98230-21-1-0060 funded four Postdoctoral Fellows: Benjamin McKenna and Christian Noack who participated in the fall jumbo program, *Universality and Integrability in Random Matrix Theory and Interacting Particle Systems,* and Jack Burkart and Therese-Marie Landry who participated in the spring programs, *Complex Dynamics: From Special Families to Natural Generalizations in One and Several Variables* and *The Analysis and Geometry of Random Spaces*, respectively.

Below is a brief description of the programs and workshops, followed by individual reports from the four NSA-funded fellows.

A. Major Programs and their Associated Workshops

If applicable, in the list of organizers of each activity the names of the **lead organizer(s)** appear in bold blue text.

Universality and Integrability in Random Matrix Theory and Interacting Particle Systems

August 16, 2021 - December 17, 2021

*Organizers: **Ivan Corwin** (Columbia University), Percy Deift (New York University, Courant Institute), Ioana Dumitriu (University of California, San Diego), Alice Guionnet (École Normale Supérieure de Lyon), Alexander Its (Indiana University--Purdue University), Herbert Spohn (Technische Universität München), Horng-Tzer Yau (Harvard University)*

The past decade has seen tremendous progress in understanding the behavior of large random matrices and interacting particle systems. Complementary methods have emerged to prove universality of these behaviors, as well as to probe their precise nature using integrable, or exactly solvable models. This program sought to reinforce and expand the fruitful interaction at the interface of these areas, as well as showcase some of the important developments and applications of the past decade.

There were three workshops associated with the *Universality and Integrability in Random Matrix Theory and Interacting Particle Systems* program. For a jumbo program, the joint Connections/Introductory workshop would normally be two-

weeks long but, due to the hybrid format necessitated by COVID-19, the joint Connections/Introductory workshop was split into two parts to reduce Zoom fatigue.

Connections and Introductory Workshop: Universality and Integrability in Random Matrix Theory and Interacting Particle Systems, Part 1 (Hybrid)
August 23, 2021 - August 27, 2021
*Organizers: Gérard Ben Arous (New York University, Courant Institute), **Ivan Corwin** (Columbia University), **Ioana Dumitriu** (University of California, San Diego), Alice Guionnet (École Normale Supérieure de Lyon), Alisa Knizel (The University of Chicago), Sylvia Serfaty (New York University, Courant Institute), Horng-Tzer Yau (Harvard University)*

This was a hybrid workshop with in-person participation by members of the semester-long program. Online participation was open to all who registered. The workshop aimed at providing participants with an overview of some of the recent developments in the topics of the semester, with a particular emphasis on universality and applications. This included universality for Wigner matrices and band matrices and quantum unique ergodicity, universality for beta ensembles and log/coulomb gases, KPZ universality class, universality in interacting particle systems, the connection between random matrices and number theory.

Connections and Introductory Workshop: Universality and Integrability in Random Matrix Theory and Interacting Particle Systems, Part 2 (Hybrid)
September 20, 2021 - September 24, 2021
*Organizers: Gérard Ben Arous (New York University, Courant Institute), **Ioana Dumitriu** (University of California, San Diego), **Alice Guionnet** (École Normale Supérieure de Lyon), Alisa Knizel (The University of Chicago), Sylvia Serfaty (New York University, Courant Institute), Horng-Tzer Yau (Harvard University)*

In addition to the goals described in Part I, this workshop also explored connections with other branches of mathematics and applications to sciences and engineering. The workshop featured presentations by both leading researchers and promising newcomers. There was a panel discussion of topics relevant to junior researchers, women, and minorities; a poster session for students and recent PhDs; and other social events.

Integrable Structures in Random Matrix Theory and Beyond (Hybrid)
October 18, 2021 - October 22, 2021
*Organizers: **Jinho Baik** (University of Michigan), Alexei Borodin (Massachusetts Institute of Technology), Tamara Grava (University of Bristol; International School for Advanced Studies (SISSA/ISAS)),*

Alexander Its (Indiana University--Purdue University), Sandrine Peche (Université de Paris VII (Denis Diderot))

Again, this was a hybrid workshop with in-person participation by members of the semester-long program and online participation was open to all who registered. This workshop focused on the integrable aspect of random matrix theory and other related probability models such as random tilings, directed polymers, and interacting particle systems. The emphasis was on communicating diverse algebraic structures in these areas which allow the asymptotic analysis possible. Some of such structures are determinantal point processes, Toeplitz and Hankel determinants, Bethe ansatz, Yang-Baxter equation, Karlin-McGregor formula, Macdonald process, and stochastic six vertex model.

Complex Dynamics: from special families to natural generalizations in one and several variables

January 18, 2022 - May 27, 2022

*Organizers: **Sarah Koch** (University of Michigan), Jasmin Raissy (Institut de Mathématiques de Bordeaux), Dierk Schleicher (Université d'Aix-Marseille (AMU)), Mitsuhiro Shishikura (Kyoto University), Dylan Thurston (Indiana University)*

Holomorphic dynamics is a vibrant field of mathematics that has seen profound progress over the past 40 years. It has numerous interconnections to other fields of mathematics and beyond. This program focused on three selected classes of dynamical systems: rational maps (postcritically finite and beyond); transcendental maps; and maps in several complex variables. Particular emphasis was placed on the interactions between each of these, and on connections with adjacent areas of mathematics.

There were three workshops associated with the *Complex Dynamics* program. The workshops were hybrid with in-person participation by members of the semester-long program. Online participation was open to all who registered.

Connections Workshop: Complex Dynamics - from special families to natural generalizations in one and several variables (Hybrid)

February 02, 2022 - February 04, 2022

*Organizers: Núria Fagella (University of Barcelona), **Tanya Firsova** (Kansas State University), Thomas Gauthier (Université Paris-Saclay), Sarah Koch (University of Michigan)*

This workshop featured lectures on a variety of topics in complex dynamics, given by prominent researchers in the field, as well as presentations by younger participants. It preceded the introductory workshop and previewed the major research themes of the semester

program. There was a panel discussion focusing on issues particularly relevant to junior researchers, women, and minorities, as well as other social events.

Introductory Workshop: Complex Dynamics - from special families to natural generalizations in one and several variables (Hybrid)
February 08, 2022 - February 17, 2022
*Organizers: Anna Miriam Benini (Università di Parma), Fabrizio Bianchi (Université de Lille), Mikhail Hlushchanka (Universiteit Utrecht), **Dylan Thurston** (Indiana University)*

This workshop was built around four minicourses that introduced the participants to a range of recent techniques in various areas of holomorphic dynamics, given by specialists in these topics. The event was complemented by a series of talks by leaders in the field, aimed at a large audience and presenting current research directions in the area.

Adventurous Berkeley Complex Dynamics (Hybrid)
May 02, 2022 - May 06, 2022
*Organizers: Mikhail Lyubich (SUNY, Stony Brook), **Jasmin Raissy** (Institut de Mathématiques de Bordeaux), **Roland Roeder** (Indiana University--Purdue University), Dierk Schleicher (Université d'Aix-Marseille)*

This topical workshop focused on complex dynamics in one and several variables. Experts in the fields of rational dynamics, transcendental dynamics, and dynamics in several complex variables were brought together in order to gain new perspectives and foster discussions in a warm and stimulating atmosphere. A special focus was placed on the interactions between one dimensional and higher dimensional complex dynamics, and on connections with adjacent areas of mathematics.

The Analysis and Geometry of Random Spaces
January 18, 2022 - May 27, 2022
*Organizers: **Mario Bonk** (University of California, Los Angeles), Joan Lind (University of Tennessee), Steffen Rohde (University of Washington), Eero Saksman (University of Helsinki), Fredrik Viklund (Royal Institute of Technology), Jang-Mei Wu (University of Illinois at Urbana-Champaign)*

This program was devoted to the investigation of universal analytic and geometric objects that arise from natural probabilistic constructions, often motivated by models in mathematical physics. Prominent examples for recent developments are the Schramm-Loewner evolution, the continuum random tree, Bernoulli percolation on the integers, random surfaces produced by Liouville Quantum Gravity, and Jordan curves and dendrites obtained from random

conformal weldings and laminations. The lack of regularity of these random structures often results in a failure of classical methods of analysis. One goal of this program was to enrich the analytic toolbox to better handle these rough structures.

There were three workshops associated with the *Analysis and Geometry of Random Spaces* program. Again, the workshops were hybrid with in-person participation by members of the semester-long program. Online participation was open to all who registered.

Connections Workshop: The Analysis and Geometry of Random Spaces (Hybrid)
January 19, 2022 - January 21, 2022
*Organizers: Mario Bonk (University of California, Los Angeles), **Joan Lind** (University of Tennessee), Eero Saksman (University of Helsinki), Jang-Mei Wu (University of Illinois at Urbana-Champaign)*

The Connections Workshop featured talks on a variety of topics related to the analysis and geometry of random spaces. It previewed the research themes of the semester program and highlighted the work of women in the field. There was a panel discussion, as well as other social events. This workshop was directly prior to the Introductory Workshop, and participants were encouraged to participate in both workshops.

Introductory Workshop: The Analysis and Geometry of Random Spaces (Hybrid)
January 24, 2022 - January 28, 2022
*Organizers: **Mario Bonk** (University of California, Los Angeles), Joan Lind (University of Tennessee), Steffen Rohde (University of Washington), Fredrik Viklund (Royal Institute of Technology)*

This workshop introduced some of the major themes in probability and geometric analysis that would be relevant for the semester-long program. A series of short mini-courses gave participants the opportunity to learn about important subjects such as the Schramm-Loewner evolution (SLE) or the Gaussian free field (GFF), for example. The workshop also included "visionary" lectures by prominent researchers who outlined fruitful directions for future research.

The Analysis and Geometry of Random Spaces (Hybrid)
March 28, 2022 - April 01, 2022
*Organizers: Nikolai Makarov (California Institute of Technology), **Steffen Rohde** (University of Washington), Eero Saksman (University of Helsinki), Amanda Turner (University of Lancaster), Fredrik Viklund (Royal Institute of Technology), Jang-Mei Wu (University of Illinois at Urbana-Champaign)*

The aim of this topical workshop was to bring together researchers whose work contributes to the study of random structures that exhibit some form of conformal self-similarity. Notable examples include the Schramm-Loewner evolution SLE, the Brownian map and random trees, Liouville Quantum Gravity, and Conformal Field Theory. A particular focus was the discussion of analytic tools needed to address the challenges arising from the often rough underlying sets and spaces.

Program 4: Complementary Program (2021-22)
August 16, 2021 - July 31, 2022
The Complementary Program has a limited number of memberships that are open to mathematicians whose interests were not closely related to the core programs but who may collaborate with members of MSRI's directorate. As part of MSRI's family friendly policy, special consideration is also given to mathematicians who are partners of an invited member of a core program.

B. Hot Topics Workshop

Again, due to COVID-19, these two workshops were entirely online.

Hot Topics: Foundations of Stable, Generalizable and Transferable Statistical Learning (Virtual)
March 07, 2022 - March 10, 2022
Org*anizers: **Peter Bühlmann** (ETH Zurich), John Duchi (Stanford University), Elizabeth Tipton (Northwestern University), Bin Yu (University of California, Berkeley)*

Despite the remarkable success in extracting information from complex and (often) large-scale datasets over the last two decades, further progress is needed to making automated statistical and machine learning algorithms more reliable, robust, interpretable and trustworthy. This workshop had its focus on foundational aspects of this goal, linking areas at the interface between statistics, optimization, machine learning and computer science, such as distributional robustness and stability, adversarial and transfer learning, generalizability and meta-analysis, and causality.

Hot Topics: Regularity Theory for Minimal Surfaces & Mean Curvature Flow (Virtual)
March 21, 2022 - March 24, 2022
Org*anizers: Christine Breiner (Brown University), Otis Chodosh (Stanford University), Luca Spolaor (University of California, San Diego), Lu Wang (Yale University)*

This workshop explored connections between the regularity theory of minimal surfaces and of mean curvature flow. Recent breakthroughs have improved our understanding of singularity formation in both settings but the current research trends are becoming increasingly disparate. Experts from both areas presented their research and there was ample free time to establish connections between the topics.

III. NSA SUPPORTED POSTDOCTORAL FELLOWS

There were 29 postdoctoral fellows who participated in the 2021-22 programs. The NSA grant, H98230-21-1-0060, partially funded four of those postdoctoral fellows. As outlined in the grant budget, we funded two postdoctoral fellows in the fall and two in the spring with an average stipend of $6,600 per month for five months. The stipends were partially funded by this NSA grant, with the remaining balance coming from other sources.

Benjamin McKenna and Christian Noack participated in the fall 2021 jumbo program, *Universality and Integrability in Random Matrix Theory and Interacting Particle Systems*:

 **McKenna, Benjamin**	**Name: Benjamin McKenna** Year of Ph.D.: 2021 Institution of Ph.D.: Courant Institute, New York City Dissertation title: Non-invariant random matrices and landscape complexity Ph.D. advisor: Gérard Ben Arous and Paul Bourgade Mentor while at MSRI: Alice Guionnet and Mariya Shcherbina Pre-MSRI Institution: Courant Institute, New York University Position: Ph.D. student Mentor (if applicable): Gérard Ben Arous and Paul Bourgade Post-MSRI Institution: IST Austria (Institute of Science and Technology) Position: Fulbright fellow (essentially postdoc) Anticipated length (or specify if tenure-track): Six months Mentor (if applicable): László Erdős (Also from September 2022 to August 2024 I will be at Harvard, Position: Postdoctoral Fellow (in CMSA, the Center of Mathematical Sciences and Applications, not the Math Department), Anticipated length:Two years, Mentor: Horng-Tzer Yau) **Postdoctoral fellow's comments:** In my fellowship, I mostly worked on two types of projects: First I worked on landscape complexity, the main area of my thesis,

	primarily working by myself but talking with Gerard Ben Arous. I started several projects in this area (non-Gaussian landscapes, TAP complexity and BRST supersymmetry), but it's not clear yet which ones will pan out. I also spent a lot of time working with Jonathan Husson and Alice Guionnet on large deviations for random matrices; along with Ofer Zeitouni we are making good progress on a joint project that different subsets of us had discussed in previous years and found too difficult at the time. Separately I am working with Jonathan on making rigorous some related works in the physics literature. Finally, I learned a lot about supersymmetry from talking with Mariya Shcherbina, which is an area I knew nothing about before. **Did you find your experience at MSRI beneficial? Why or why not?** Absolutely! On an emotional level it was so, so great seeing so many people in three dimensions. I really feel like a part of a community, which was sometimes hard to believe in the early pandemic. Mathematically, I think the kinds of questions I'm asking matured a lot from talking to everyone here, even if I didn't get any papers actually done yet - my personal list of problems changed very significantly in the last four months, and I have a more realistic sense of what's interesting and what's possible. It was also great for me to start working with peers rather than just senior people, and also to practice juggling multiple projects (until now I had only worked intensively on one project at a time). In fact I found juggling multiple projects to be unexpectedly difficult, but it's an important skill to have and I was glad for the chance to start practicing it. **Do you feel your fellowship has helped (or will help) you with finding a future position? If so, in what way?** Yes, certainly. I had the opportunity to build out my professional network, both of people I know -- i.e. professors who can attach my face to my name -- and people I've worked with, in that it's important to collaborate not just with senior faculty but also with one's peers, and I could meet and work with such peers here. **Please comment on your experience with the hybrid format of the program. Was it beneficial to have both virtual and in-person elements? Are there ways the experience could be improved?** I did not do that much hybrid stuff. I did watch some talks virtually live, but the most important thing is that the talks are recorded forever, which is amazing, for a few reasons: (a) I watched a handful of talks shortly after they happened (if I had another meeting during the actual appointment), (b) some talks I did not watch now but want to watch after the program, when I have time to catch up, (c) some talks I don't have particular plans to watch but might watch in a few years if I get interested in a topic, (d) I can put recordings of my own talks on my website and use them on the job market. I never really used Sococo and did not really collaborate

	with any virtual participants; I think if there had been participants I really wanted to work with who happened to be virtual I would have made it happen, but the bumping-into-and-chatting connections didn't really happen. The main drawback of virtual participation for me is that I sort of hate Zoom at this point, and try to spend as little time on it as possible. Also, I ended up spending about one day a week working from home, but that was to actually get a bunch of work done so I didn't log into anything virtual or talk to anybody. I can't think of anything that could be improved as an in-person participant. I was super happy talking to people in person and did as little virtual stuff as possible, and it was great. I imagine stuff could be improved for the virtual participants - I feel a little bad for them - but I'm not sure what.

 **Noack, Christian**	**Name: Christian Noack** Year of Ph.D: 2018 Institution of Ph.D.: University of Wisconsin- Madison Dissertation title: On stationary exactly solvable 1+1 dimensional lattice directed polymer models Ph.D. advisor: Timo Seppalainen Mentor while at MSRI: Shirshendu Ganguli and Allan Hamond Pre-MSRI Institution: Cornell University Position at that institution: Visiting Assistant Professor Mentor (if applicable): Philippe Sosoe Post-MSRI institution (or company): Purdue Position: Visiting Assistant Professor Anticipated length (or specify if tenure-track): 6 months Mentor (if applicable): n/a **Postdoctoral fellow's comments:** I attended several interesting lectures and workshops, learned a lot of new material, got ideas for future research, and learned professional skills/ how to best go about obtaining a tenure-track position. Giving a talk in front of world class experts. Collaborating with several other MSRI postdocs and members: • Philippe Sosoe and I are in an exploratory phase of a paper inspired by an MSRI talk • Yier Lin, Chris Janjigian, Firas Rasoul-Agha, Timo Seppalainen, and I are in the rough draft phase of a new paper concerning geodesics. **Did you find your experience at MSRI beneficial? Why or why not?** Yes, very. For every single reason mentioned above.

	Do you feel your fellowship has helped (or will help) you with finding a future position? If so, in what way? Yes. The professional development workshops were very illuminating into how the hiring side functions, and specifically what they look for and how they hire. **Please comment on your experience with the hybrid format of the program. Was it beneficial to have both virtual and in-person elements? Are there ways the experience could be improved?** The hybrid format was absolutely crucial for me. I attended most things online, as my allergies have gotten very bad, and the lack of rain in Berkeley and warmer temperature kept them going constantly. I therefore would generally fail the UC-Berkeley "daily prescreen" which made attending things via Zoom essential. For this reason I collaborated with several people virtually. Benefits were the ability to still interact and attend events while not able to be on campus. Downside, as always with mathematics on Zoom, is that there's no comparison to in person collaboration in front of a chalk board (but that is a general comment about Zoom, and in no way a negative reflection on the MSRI). I really don't think much could have been improved. It simply is the hand we were dealt this semester with covid, delta, omicron, etc. The constant mask wearing for long periods of time made me extremely uncomfortable when attending in person, but I understand and recommend this be the requirement for the foreseeable future. The only way to improve the experience: help solve the pandemic and its mutations so that we can attend lectures and collaborate in person mask-free!!

Therese Landry participated in the spring 2021 program, *The Analysis and Geometry of Random Spaces:*

 **Landry, Therese-Marie**	**Name: Therese-Marie Basa Landry** Year of Ph.D: 2022 Institution of Ph.D.: University of California, Riverside Dissertation title: Towards Analysis on Fractals: Piecewise C^1-Fractal Curves, Spectral Triples, and the Gromov-Hausdorff Propinquity Ph.D. advisor: Michel Lapidus Mentor while at MSRI: Masha Gordina Pre-MSRI Institution: University of California, Riverside Position at that institution: PhD Student Mentor (if applicable): Michel Lapidus

	Post-MSRI institution (or company): Fields Institute (7/1/22-12/31/22); University of California, Santa Barbara (starts 7/1/22, renewable up to 3 years) Position: Postdoctoral Fellow with the Thematic Program on Nonsmooth and Lorentzian Geometry (Fields Institute), Visiting Assistant Professor (UC Santa Barbara) Anticipated length (or specify if tenure-track): Fields Postdoctoral Fellowship (6 months), UC Santa Barbara Visiting Assistant Professor Position (renewable up to 3 years) Mentor (if applicable): George Elliott (for the Fields Institute position), Bjorn Birnir (for the UC Santa Barbara position) **Postdoctoral fellow's comments:** I am very excited about the opportunities I have had during this program to both broaden my research scope and refine my non-commutative geometry toolkit. Spectral triples are noncommutative generalizations of differentiable structure. My time at MSRI afforded me the chance to develop a spectral triple on an inductive limit C*-algebra that can also be realized as an inductive limit of spectral triples. Spectral triples exist for inductive limit C*-algebras that are noncommutative Cantor sets, which are inductive limits of finite-dimensional C*-algebras. This spectral triple is a noncommutative solenoid, which is an inductive limit of rotation algebras. Noncommutative solenoids can also be represented as twisted group C*-algebras and a bounded doubling condition with respect to length functions was used to build a spectral triple that also induces quantum compact metric space structure. I am now working on a paper describing these results and hope to soon submit it for publication. I have also begun another project developing semifinite spectral triples, which are an extension of spectral triples where the compactness requirements for the generalized Dirac operator are relaxed, thereby extending the range of settings which can be viewed as noncommutative Riemannian manifolds. My long term goals as a noncommutative fractal geometer include the development of spectral triples that are suitable for capturing the essential aspects of metric measure spaces, as well as that of Dirichlet forms. The lectures given by Mario Bonk and Pekka Pankka on conformal dimension gave me a good sense of developments in the subject. I am also glad to have met Nages Shanmugalingam. As a noncommutative geometer looking to build structures suitable for analysis on fractals, I found her talks very informative, as well as those given by Li Chen on Dirichlet forms. Mathav Murugan also directed my attention to a paper by Davies on noncommutative metrics and analysis on graphs and as a consequence of my time and interactions with the members of this program, I feel ready to start considering some of the questions posed in that paper. I am also glad to have the benefit of interactions with established probabilists like Masha Gordina. During the workshop associated with the program, I started considering some ideas for operator algebras on random fractals which I hope to pursue in future work. Most importantly, I

	established a new network of contacts with whom I feel comfortable soliciting research perspectives and advice. **Did you find your experience at MSRI beneficial? Why or why not?** My time at MSRI was an absolutely transformational one. When I was a Masters student at San Francisco State, I used to attend the Connections Workshops, so I was more than elated at the chance to be at MSRI for my first post-doctoral position. As a non-commutative fractal geometer, participating in the Analysis and Geometry of Random Spaces program gave me an opportunity to branch out research-wise and develop some new perspectives. In particular, I am grateful to the research members of this program for their generosity with their time, expertise, and experience. I am also thankful to David Eisenbud and Hélène Barcelo for their conversation and professional advice at this critical time in my transition from graduate student to postdoc. For an early career mathematician like myself, the experience of the MSRI community in residence at the same time was particularly validating for my sense of belonging in the greater mathematical community. Besides getting some new ideas for research and other kinds of professional initiatives, I feel the kindness and professionalism of everyone at MSRI also gave me the inspiration and confidence to pursue them. **Do you feel your fellowship has helped (or will help) you with finding a future position? If so, in what way?** I think my next two postdoctoral positions can be directly traced to my MSRI postdoc. This is because when I applied for the Fields Institute Postdoctoral Fellowship last fall, I think that having the (then) upcoming MSRI Postdoctoral Fellowship on my CV strengthened my application substantially. Since I received the offer from the Fields Institute the following January, I was able to update all my other applications with both this development and the opportunity I had at MSRI to co-organize the Career Development Panels for the postdocs. I then received the offer of a Visiting Assistant Professor position at UC Santa Barbara. I also think that getting to be around so many experienced mathematicians while navigating the job market had a positive impact on the choices I made and the attitude with which I approached the process. **Please comment on your experience with the hybrid format of the program. Was it beneficial to have both virtual and in-person elements? Are there ways the experience could be improved?** Since this was my first in-person program after the start of the pandemic, I did not attend any lectures that were given virtually or attend any lectures virtually. That said, I think I was fortunate to be able to make such a priority and I do think virtual activities should remain a component of MSRI programs as they allow for greater flexibility in participation for those who are caring for family members or are having visa issues.

Jack Burkart participated in the spring 2021 program, *Complex Dynamics: From Special Families to Natural Generalizations in One and Several Variables:*

Burkart, Jack

Name: Jack Burkart
Year of Ph.D: May 2021
Institution of Ph.D.: Stony Brook University
Dissertation title: Transcendental Julia Sets with Fractional Packing Dimension
Ph.D. advisor: Christopher Bishop

Mentor while at MSRI: André de Carvalho

Pre-MSRI Institution: University of Wisconsin Madison
Position at that institution: Postdoc
Mentor (if applicable): Alexei Poltoratski

Post-MSRI institution (or company): University of Wisconsin Madison
Position: Postdoc
Anticipated length (or specify if tenure-track): Until Spring 2024
Mentor (if applicable): Alexei Poltoratski & Andrew Zimmer

Postdoctoral fellow's comments:
Initially when I arrived, I collaborated on a previously ongoing project with Leticia Pardo-Simon and Adi Glucksam about the max modulus set of entire functions. My contribution ultimately didn't work out, but we still had good discussions and I learned a great number of interesting new problems I may be able to think about (and have people to discuss with!) in the future. I have started collaborating with Lukas Geyer on a project on the Hausdorff dimension of Julia sets of non-polynomial entire functions. While the work is preliminary and many things need to be checked, progress so far is promising. I think this will become a paper. I spent time finishing the writeup on one paper, fixing some lemmas and small but tedious issues, and responding to a referee report for another. I plan on having a discussion with Tim Mesikepp in the other program about some topic of mutual interest in geometric function theory, and I hope that can lead to a collaboration moving forward. I spent a good deal of time discussing other open questions I have informally with others, and I learned some new technical tools in complex dynamics that I think will help me moving forward.

Outside of doing mathematics, I co-organized with Therese Marie Landry the Career Development Seminar, on topics of writing referee reports, grant writing, collaboration, diversity equity and inclusion, and opportunities in industry. This was a good deal of work but ultimately enjoyable. I gave many research and expository talks in both senior and junior seminar series. While I am officially part of the complex dynamics program, I enjoyed interacting with the analysis and probability group, and found some common overlap with several

	individuals that I did not expect (Pekka Pankka, and Vyron Vellis, who visited for a couple weeks). **Did you find your experience at MSRI beneficial? Why or why not?** I did. Professionally, meeting a large group of new people will pay off dividends later on in my career. Mathematically, I started one very promising new project and I think there is potential for one more. I learned many things beyond my area of expertise as well - I benefitted from having time to simply read and think I wouldn't otherwise have had. Organizing a seminar is also very valuable experience I can use going forward. I particularly enjoyed being able to spend time with many research like-minded postdocs and graduate students. Meeting so many young specialists in the fields you are interested in is a treat. I also enjoyed working with my mentor, André. We don't have much overlapping research interests, but we had a lot of productive career discussions, and he gave me some great help on my talks and other things I participated in! **Do you feel your fellowship has helped (or will help) you with finding a future position? If so, in what way?** I do think so. I met a huge number of new people, which will keep me alert to different opportunities I would otherwise have been unaware of. I got to learn some new mathematical tools as well, and I hope I can use them moving forward to write more papers. **Please comment on your experience with the hybrid format of the program. Was it beneficial to have both virtual and in-person elements? Are there ways the experience could be improved?** I was in person the whole semester and infrequently used the hybrid structure to participate. It was mostly when I just wanted to watch a talk from outside of my office. I think having the option added some great flexibility. I did not collaborate much with the virtual participants. It's difficult to find time not around talks to have discussions with them; this is simply a difficulty around zoom though, and I am not sure how that can be realistically improved.

III. PUBLICATIONS SUMMARY

The four NSA funded postdoctoral fellows worked on several projects during the program and by the end of the Spring 2021 semester, they list the following papers as direct outcomes of their fellowship at MSRI.

Postdoc	Paper Titles	Co-author(s)	Paper Status
Jack Burkart	A Jordan Curve that Cannot be Crossed by Rectifiable Arcs on a set of zero length		Posted
Jack Burkart	Interpolation of Power Mappings	Kirill Lazebnik	Accepted
Benjamin McKenna	Large deviations for the largest eigenvalue of inhomogeneous sample covariance matrices	Jonathan Husson	Rough/Draft
Benjamin McKenna	Large deviations for the largest eigenvalue of perturbed Rademacher matrices	Alice Guionnet, Jonathan Husson, Ofer Zeitouni	Rough/Draft
Christian Noack	On Geodesics and their lifting to the Beta RWRE	Christopher Janjigian, Yier Lin, Timo Seppalainen	Rough/Draft
Therese Landry	Spectral Triples on Noncommutative Solenoids	Carla Farsi, Nadia Larsen, Judith Packer	Rough/Draft