

**Final Report on the  
Mathematical Sciences Research Institute  
2020-21 Activities supported by NSA Grant  
H98230-20-1-0255  
Support of Early Career Researchers at MSRI  
6/1/20- 5/31/21**

**July 2021**

**Mathematical Sciences Research Institute  
NSA Final Report for H98230-20-1-0255**

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## 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.

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 a Hot Topics workshop. 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 [www.msri.org](http://www.msri.org). This report covers only the events listed above, which are the primary activities in which MSRI's postdoctoral fellows participate.

## II. OVERVIEW OF ACTIVITIES 2020-21

The year 2020-21 was an exciting one. In fall 2020, we held two programs: *Decidability, Definability and Computability in Number Theory: Part 1* co-led by Valentina Harizanov (George Washington University) and Alexandra Shlapentokh (East Carolina University) and *Random and Arithmetic Structures in Topology* co-led by Richard Canary (University of Michigan) and Martin Bridgeman (Boston College). In spring 2021, we held the program, *Mathematical Problems in Fluid Dynamics*, co-led by Daniel Tataru (University of California, Berkeley) and Mihaela Ifrim (University of Wisconsin-Madison). While MSRI was open to researchers that could travel to Berkeley, due to the COVID-19 pandemic, MSRI held its scientific activities online through virtual seminars, meetings, and workshops. About 20 researchers were able to be in residence at MSRI for period of time ranging from 1 to 4 months. MSRI also hosted a small Complementary Program for mathematicians whose interests were closely related to the research area of the directorate. The three 2020-21 programs are briefly summarized in Section II.

There were 199 researchers who participated in the 2020-21 programs. Of those members, there were 27 Postdoctoral Fellows, 62 Organizers & Research Professors, 73 Research Members, and 37 Program Associates (Graduate Students). All postdocs received their promised fellowship, regardless of whether or not they were able to travel to MSRI. All postdocs signed an affidavit stating that they were not receiving any other compensation and that they were fully engaged in the programmatic activities, whether in person or online.

The NSA grant H98230-20-1-0255 funded four Postdoctoral Fellows: David Corwin who participated in the fall program, *Decidability, Definability and Computability in Number Theory: Part 1*; Nicholas Miller who participated in the fall program, *Random and Arithmetic Structures in Topology*, and Trevor Leslie and Evan Miller who participated in the spring program, *Mathematical Problems in Fluid Dynamics*. Two of these postdocs, Nicholas Miller and Evan Miller, were able to be in residence at MSRI while David Corwin and Trevor Leslie remained at their home institutions.

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**

In the list of organizers of each activity, an asterisk (\*) denotes lead organizer(s).

#### **Decidability, Definability and Computability in Number Theory: Part 1 (Virtual)**

August 17, 2020 - December 18, 2020

*Organizers: Valentina Harizanov\* (George Washington University), Maryanthe Malliaris (University of Chicago), Barry Mazur (Harvard University), Russell Miller (Queens College, CUNY; CUNY, Graduate Center), Jonathan Pila (University of Oxford), Thomas Scanlon (University of California, Berkeley), Alexandra Shlapentokh\* (East Carolina University), Carlos Videla (Mount Royal University)*

This program focused on the two-way interaction of logical ideas and techniques, such as definability from model theory and decidability from computability theory, with fundamental problems in number theory. These included analogues of Hilbert's tenth problem, isolating properties of fields of algebraic numbers which related to undecidability, decision problems around linear recurrence and algebraic differential equations, the relation of transcendence results and conjectures to decidability and decision problems, and some problems in anabelian geometry and field arithmetic. We covered this specific interface across a range of problems.

There were three workshops originally planned for the *Decidability, Definability and Computability in Number Theory* program. Two of these (the Connections and the Introductory workshops) were postponed to summer 2022 in light of the COVID-19 pandemic.

### **Random and Arithmetic Structures in Topology**

**(Virtual)**

August 17, 2020 – December 18, 2020

*Organizers of the original program: Nicolas Bergeron (École Normale Supérieure), Jeffrey Brock (Yale University), Alexander Furman (University of Illinois at Chicago), Tsachik Gelander (Weizmann Institute of Science), Ursula Hamenstädt (Rheinische Friedrich-Wilhelms-Universität Bonn), Fanny Kassel (Institut des Hautes Études Scientifiques (IHES)), Alan Reid\* (Rice University).*

*Organizers of the virtual program: Dick Canary (University of Michigan) Martin Bridgeman (Boston College).*

The use of dynamical invariants has long been a staple of geometry and topology, from rigidity theorems, to classification theorems, to the general study of lattices and of the mapping class group. More recently, random structures in topology and notions of probabilistic geometric convergence have played a critical role in testing the robustness of conjectures in the arithmetic setting. This program focused on invariants in topology, geometry, and the dynamics of group actions linked to random constructions.

There were originally three workshops planned for the *Random and Arithmetic Structures in Topology* program. Two of the workshops were cancelled in light of the COVID-19 pandemic, and the third workshop was held virtually:

### **Random & Arithmetic Structures in Topology: Introductory Workshop**

**(Virtual)**

August 25, 2020 – September 11, 2020

*Organizers: Martin Bridgeman (Boston College), Richard Canary (University of Michigan), Michelle Chu (University of Illinois at Chicago), Tommaso Cremaschi (University of Southern California), James Farre (Yale University), David Fisher (Indiana University)*

This Introductory workshop took place virtually, over the course of three weeks. There were two mini-courses and two talks by MSRI Postdoctoral Fellows each week.

## **Mathematical Problems in Fluid Dynamics**

**(Virtual)**

January 19, 2021 – May 28, 2021

*Organizers: Thomas Alazard (Ecole Normale Supérieure Paris-Saclay; Centre National de la Recherche Scientifique (CNRS)), Hajer Bahouri (Laboratoire Jacques-Louis Lions; Centre National de la Recherche Scientifique (CNRS)), Mihaela Ifrim\* (University of Wisconsin-Madison), Igor Kukavica (University of Southern California), David Lannes (Institut de Mathématiques de Bordeaux; Centre National de la Recherche Scientifique (CNRS)), Daniel Tataru\* (University of California, Berkeley)*

Fluid dynamics is one of the classical areas of partial differential equations, and has been the subject of extensive research over hundreds of years. It is perhaps one of the most challenging and exciting fields of scientific pursuit simply because of the complexity of the subject and the endless breadth of applications. The focus of the program was on incompressible fluids, of which water was a primary example. The workshop focused on the fundamental equations in this area – the well-known Euler equations for inviscid fluids, and the Navier-Stokes equations for the viscous fluids. Relating the two is the problem of the zero viscosity limit, and its connection to the phenomena of turbulence. Water waves, or more generally interface problems in fluids, represented another target area for the program. Both theoretical and numerical aspects were considered.

Workshops associated with the *Mathematical Problems of Fluid Dynamics* program:

### **Connections Workshop: Mathematical Problems in Fluid Dynamics**

**(Virtual)**

January 20, 2021 – January 22, 2021

*Organizers: Hajer Bahouri (Laboratoire Jacques-Louis Lions; Centre National de la Recherche Scientifique (CNRS)), Juhi Jang (University of Southern California), Anna Mazzucato\* (Pennsylvania State University), Sijue Wu (University of Michigan)*

This workshop featured talks by prominent female mathematicians whose research lies in and interfaces with mathematical fluids featuring water waves, free boundaries, fluid structures, viscous fluids and turbulence. The talks were appropriate for graduate students, post-docs, and researchers in areas mentioned above. There was also a panel discussion. This workshop was open to all mathematicians.

### **Introductory Workshop: Mathematical Problems in Fluid Dynamics**

**(Virtual)**

January 25, 2021 - February 05, 2021

*Organizers: Nicolas Burq (Université de Paris XI), Anne-Laure Dalibard (Université de Paris VI (Pierre et Marie Curie)), Jean Marc Delort*

*(Université de Paris XIII (Paris-Nord)), Mihaela Ifrim\* (University of Wisconsin-Madison), Irena Lasiecka (University of Memphis), Vladimir Sverak (University of Minnesota Twin Cities)*

The workshop addressed topics in the PDE analysis of the basic equations of the incompressible fluid dynamics (the Euler equations for inviscid flows, the Navier Stokes equations for viscous flows), interface problems (water waves), and other related equations. Open problems and connections to related branches of mathematics were discussed, including the phenomena of turbulence and the zero viscosity limit. Both theoretical and numerical aspects of these topics were considered. There were some colloquium style lectures as well as shorter research talks. The workshop was open to all.

### **Recent Developments in Fluid Dynamics**

**(Virtual)**

April 12, 2021 – April 30, 2021

*Organizers: Thomas Alazard (École Normale Supérieure Paris-Saclay; Centre National de la Recherche Scientifique (CNRS)), Hajer Bahouri (Laboratoire Jacques-Louis Lions; Centre National de la Recherche Scientifique (CNRS)), Mihaela Ifrim (University of Wisconsin-Madison), Igor Kukavica (University of Southern California), David Lannes (Institut de Mathématiques de Bordeaux; Centre National de la Recherche Scientifique (CNRS)), Daniel Tataru\* (University of California, Berkeley)*

This workshop brought together a broad array of researchers working on incompressible fluid dynamics. Some of the key topics covered were Euler flows, Navier Stokes equations as well as water wave flows and associated model equations. Some emphasis was placed on numerical analysis of the above evolutions.

### **Program 4: Complementary Program (2020-21)**

**(Virtual)**

August 17, 2020 – May 28, 2021

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 friendly family policy, special consideration is given to mathematicians who are partners of an invited member of a core program.

## B. Hot Topics Workshop

### Hot Topics: Topological Insights in Neuroscience (Virtual)

May 4-7, 2021 and May 10-11, 2021

Organizers: *Carina Curto (Pennsylvania State University), Chad Giusti (University of Delaware), Kathryn Hess\* (École Polytechnique Fédérale de Lausanne (EPFL)), Ran Levi (University of Aberdeen)*

The talks in this workshop presented a wide array of current applications of topology in neuroscience, including classification and synthesis of neuron morphologies, analysis of synaptic plasticity, algebraic analysis of the neural code, topological analysis of neural networks and their dynamics, topological decoding of neural activity, diagnosis of traumatic brain injuries, and topological biomarkers for psychiatric disease. Some of the talks were devoted to promising new directions in algebraic topology that have been inspired by neuroscience.

## III. PARTICIPATION SUMMARY

### A. All MSRI Members

The table below indicates the number of participants for the major programs and workshops that took place at MSRI during the 2020-21 academic year.

DATES	ACTIVITY TYPE	TITLE	PARTICIPANTS
6/13/20-7/26/20	MSRI-UP	MSRI-UP 2020: Branched Covers of Curves	17
6/15/20-6/26/20	Workshop	2020 African Diaspora Joint Mathematics Workshop (ADJOINT)	20
6/29/20-7/10/20	Summer Graduate School	Séminaire de Mathématiques Supérieures 2020: Discrete Probability, Physics and Algorithms	15
7/27/20-8/07/20	Summer Graduate School	Introduction to Water Waves	53
8/12/20-8/14/20	Workshop	Mathematical Models for Prediction and Control of Epidemics	484
<b>Fall 2020</b>	<b>Scientific Program</b>	<b>Decidability, Definability and Computability in Number Theory: Part 1</b>	<b>51</b>
<b>Fall 2020</b>	<b>Scientific Program</b>	<b>Random and Arithmetic Structures in Topology</b>	<b>57</b>
8/25/20-9/11/20	Programmatic Workshop	Random and Arithmetic Structures in Topology: Introductory Workshop	175




Spring 2020	Scientific Program	Mathematical Problems in Fluid Dynamics	88
1/20/21-1/22/21	Programmatic Workshop	Connections Workshop: Mathematical Problems in Fluid Dynamics	161
1/25/21-2/05/21	Programmatic Workshop	Introductory Workshop: Mathematical Problems in Fluid Dynamics	239
4/12/21-4/30/21	Programmatic Workshop	Recent Developments in Fluid Dynamics	239
<b>8/17/20-5/28/21</b>	<b>Scientific Program</b>	<b>Complementary Program 2020-21</b>	<b>3</b>
4/29/21	Workshop	Critical Issues in Mathematics Education 2021: Initiating, Sustaining, and Researching Mathematics Department Transformation of Introductory Courses for STEM Majors	147
5/04/21-5/11/21	Workshop	Hot Topics: Topological Insights in Neuroscience	218

## B. NSA supported Postdoctoral Fellows

There were 27 postdoctoral fellows who participated in the 2020-21 programs. The NSA grant, H98230-20-1-0255, 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 \$6,300 per month for five months. Since the provisional Indirect Cost rate increased from the proposed 22.96% to 28.82%, we reduced the stipend charged to the grant for one of the post docs.

David Corwin participated in the fall 2020 program, *Decidability, Definability and Computability in Number Theory, Part 1*:

 <b>Corwin, David</b>	<p><b>Name: David Corwin</b>  Year of Ph.D: 2018  Institution of Ph.D.: Massachusetts Institute of Technology (MIT)  Dissertation title: Obstructions to Integral and Rational Points  Ph.D. advisor: Bjorn Poonen  Mentor while at MSRI: Prof. Barry Mazur</p> <p>Pre-MSRI Institution: University of California, Berkeley  Position at that institution: RTG Postdoctoral Scholar  Mentor: Martin Olsson</p> <p>Post MSRI institution: University of California, Berkeley  Position: RTG Postdoctoral Scholar  Anticipated length: 6 months (will then go to a different position)</p>
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**Postdoctoral fellow's comments:**

I attended various seminars, especially the Diophantine Problems seminar. I also gave a couple of introductory talks about rational points on algebraic curves.

I got the most out of my conversations with my mentor, Barry Mazur. He asked me questions about work of Bas Edixhoven on geometric quadratic Chabauty, which led to a note I wrote about the limits of geometric non-abelian Chabauty's method. He also went over my work on motivic non-abelian Chabauty's method for a punctured elliptic curve and asked various helpful questions.

That gets us to the biggest focus of my time at MSRI, which was on research projects that I had previously started. I was especially working on a project to rigorously determine the set of  $\mathbb{Z}[1/2]$ -points on a punctured elliptic curve using non-abelian Chabauty's method of Minhyong Kim. This is interesting because it's a case in which quadratic Chabauty does not apply, while quadratic Chabauty accounts for almost all examples in which one has been able to explicitly determine the set of integral or rational points on a variety using non-abelian Chabauty's method.

I also have made some progress on a project to compute étale homotopy obstructions to rational points on del Pezzo surfaces over a p-adic function field. I had the basic idea for this for a while and had written some ideas on paper. But I wrote up a lot of these ideas during my time at MSRI, now having a 21-page writeup. I also came to better understand how gerbes might relate to the question of lifting points to the universal torsor. There's still a lot more to do before this project is complete, but I made a lot of progress on it.

I also made some progress on a project I had been working on for a while regarding cuspidal fundamental group sections on higher-dimensional varieties. But rather than solve the problem, I noticed a problem with my method, and I haven't yet been able to fix it. I also added some material this semester to my writeup (which I had started long before MSRI) about how the subject relates to logarithmic fundamental groups.

**Did you find your experience at MSRI beneficial? Why or why not?**

I would say it was especially beneficial in that: 1) I got to talk to Barry Mazur one hour every week and 2) I had a semester where my only focus was on research, so I advanced much more on research than in previous semesters.

**Do you feel your fellowship has helped (or will help) you with finding a future position? If so, in what way?**

It definitely helps me in finding a future position with all the research progress I made!

**Please comment on your experience with the online format of the program. Were there any surprising benefits from an online meeting? What were the most important factors that were missing compared to an in person meeting? How could the experience be improved?**

As I've told the administration, I think it was unfortunate that: 1) The RAS and DDC teas were separate (really not sure why this happened) and 2) there was no DDC introductory workshop (I know this was because they wanted to have a DDC Part II in 2022).

I would say that 2) was unfortunate specifically because DDC was bringing together people from somewhat different fields. I think there were roughly three areas that people came from: 1) computability theory 2) model theory and valuation theory 3) number theory. These three groups spoke different languages. In the end, I felt like the program was dominated by 2). It would have been great to have some introductory lectures in 1) and 2) so that a number theorist like me could get the basics down.

There was an introductory series in model theory, although I already knew basic model theory, and I felt that more was needed. And there wasn't really anything on valuation theory or computability theory. In theory, I should re-watch some of the talks from earlier in the semester after having seen those lectures.

Here's another result of the online format: The seminars could invite anyone to speak, not just people who were in Berkeley. The result was that the quality of the research presented was probably a lot higher. The downside was that there was less focus on the people who were actually in the program. I was not asked to speak in anything other than the junior seminar, until late in the semester when the leadership of MSRI intervened and made sure that I got invited to something. I don't think anyone intended to leave me out; rather, there was so much focus on outside speakers that some of the program participants fell through the cracks.

Nicholas Miller participated in the fall 2020 program, *Random and Arithmetic Structures in Topology*:



**Miller, Nicholas**

**Name: Nicholas Miller**

Year of Ph.D.: 2017

Institution of Ph.D.: Purdue University

Dissertation title: The Geodesic Geometry of Arithmetic Orbifolds

Ph.D. advisor: David Ben McReynolds

Mentor while at MSRI: David Fisher

Pre-MSRI Institution: University of California, Berkeley

Position at that institution: Morrey Visiting Assistant Professor

Mentor (if applicable): Ian Agol

Post-MSRI institution: University of California, Berkeley

Position: Morrey Visiting Assistant Professor

Anticipated length (or specify if tenure-track): 3 years total (1.5 more)

Mentor (if applicable): Ian Agol

**Postdoctoral fellow's comments:**

I have spent the semester working on a few projects as well as being involved in several organizing aspects for the MSRI program. I was a lead organizer of the RAS Research seminar, the main seminar in which senior members of the program presented their research, and I was also a co-organizer of the SOQUAGAT seminar, a seminar meant to foster collaboration between junior members of the program by exposing them to some open questions in arithmetic, geometry, and topology. I have also been a frequent attendee of several other RAS seminars over the course of the semester.

As for research projects, being at MSRI has afforded me the luxury of finishing some old projects as well as the time to explore the beginnings of new projects. Briefly, I am in the process of finishing a paper regarding Azumaya algebras and once punctured torus bundles, which studies Azumaya algebras over the character variety of certain hyperbolic 3-manifolds and is a follow-up to the work of Chinburg-Reid-Stover on similar topics. This paper was written entirely this semester. I have also begun working on projects with Fisher, Lafont, and Stover trying to understand higher dimensional hyperbolic manifolds as well as with Lafont and McReynolds trying to recursively enumerate certain classes of higher rank arithmetic lattices. In addition to this, I have been talking with Soumya Sankar, another postdoc of the RAS program, about some problems regarding congruence covers of hyperbolic 3-manifolds, a conversation directly related to a talk in the SOQUAGAT seminar. On my own, I have also immersed myself in learning about deformations of representations, such as bending constructions and their cohomological interpretation. For those topics, I have some potential projects for myself that I would like to work on in the future and very much value having been afforded the time to learn about

this topic.

**Did you find your experience at MSRI beneficial? Why or why not?**

I think the experience at MSRI was as beneficial as it could be during the pandemic. Though the activities and collaboration were inherently not the same as they could have been during a time when everyone could be present in the building, I think the flexibility it afforded me as well as the activities that did arise were incredible beneficial to me. Moreover, the ability to have a physical office at MSRI during the pandemic was extremely helpful for me to be able to focus and get work done.

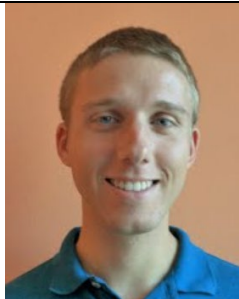
**Do you feel your fellowship has helped (or will help) you with finding a future position? If so, in what way?**

I definitely think that my MSRI position will help me find a permanent position in the future. The MSRI position has provided me with an opportunity to have a full semester of research, when I normally would be teaching two upper division undergraduate courses. This is a huge relief, especially during the pandemic, as it has allowed me to focus on research which may be vital to me getting a job when I apply next fall. Additionally, I have been fortunate enough to be named the McDuff postdoctoral scholar for this program and I believe that this named position will be evaluated favorably for me when I am being reviewed for jobs.

**Please comment on your experience with the online format of the program. Were there any surprising benefits from an online meeting? What were the most important factors that were missing compared to an in person meeting? How could the experience be improved?**

In general, I thought the online format of MSRI was decent and the actual seminars ran as they would have if the semester were in person. I think there were relatively few technical hiccups, entirely user error when they did exist, so in that sense the amount of talks was relatively similar. I personally do not necessarily benefit from having online meetings, I find it hard to focus at a screen for several hours a day so from that perspective I think there weren't necessarily benefits. I also think it's relatively hard to have spontaneous collaboration in an online format. In that regard, it might be nice if collaboration was a bit more forced in the future to account for this. For example the organizers could construct small reading groups (say, 3-7 people) that meet every week, allowing them to choose something to read, and force small group interactions that way. Perhaps more spontaneous collaboration or at least more small group discussions would then grow out of those groups.

Trevor Leslie and Evan Miller participated in the spring 2021 program, *Mathematical Problems in Fluid Dynamics*:



**Leslie, Trevor**

**Name: Trevor Leslie**

Year of Ph.D: 2018

Institution of Ph.D.: University of Illinois at Chicago

Dissertation title: Regularity and Energy Laws in Hydrodynamic Models of Newtonian Fluids and Collective Behavior

Ph.D. advisor: Roman Shvydkoy

Mentor while at MSRI: Hajer Bahouri

Pre-MSRI Institution: University of Wisconsin, Madison

Position: Van Vleck Visiting Asst. Professor (postdoctoral)

Mentor (if applicable): Sergey Denisov

Post-MSRI institution: University of Southern California

Position: Assistant Professor (NTT) (postdoctoral)

Anticipated length (or specify if tenure-track): 1-3 years

Mentor (if applicable):

**Postdoctoral fellow's comments:**

During my fellowship, my primary focus was the work I performed with my mentor, Hajer Bahouri, and her collaborator, Galina Perelman. This project was relatively far from the main thrust of my previous research, and I had to devote a significant amount of time to learning the tools necessary to tackle the problem we were considering. However, we are relatively close to finishing a paper together, and I anticipate we will post it to the ArXiv in late June or July.

The fellowship also provided me the time to continue another project that was already in the works, but still in the early stages at the beginning of the program. My collaborator Changhui Tan (University of South Carolina) and I will likely post a preprint resulting from this project sometime in mid-June.

In addition to the two projects mentioned above, I attended many of the seminars hosted by MSRI (and spoke at one), and I attended some of the classes taught by Thomas Alazard.

**Did you find your experience at MSRI beneficial? Why or why not?**

Absolutely. By far the most beneficial part of the program for me was the mentorship component. As I mentioned above, the project that I worked on with Hajer Bahouri and Galina Perelman was relatively far from the kind of research I've been doing previously. Without their guidance in a mentorship capacity, I'm highly doubtful I would have ever seriously explored this area, as there is a

	<p>relatively steep learning curve (up which they patiently guided me) that would have otherwise been a formidable barrier to entry. I remain far from an expert in this area, but I can now see myself completing future projects related to our joint work. Thus, this program opened an entirely new research direction for me, broadening the scope of my research interests and my collaborative network.</p> <p>As I also mentioned above, the extra time that I was able to spend devoted solely to research was instrumental in speeding up the project I had already started before the program. Overall, my productivity this semester is probably the highest it has ever been.</p> <p><b>Do you feel your fellowship has helped (or will help) you with finding a future position? If so, in what way?</b></p> <p>Yes. I accepted an offer for a postdoctoral position at USC in January. It's hard to know for certain whether the fact that the MSRI fellowship was on my resume played a role in that offer, but I'm sure it didn't hurt. When I apply for tenure-track jobs in the next job cycle(s), I'm convinced that the broadening of my collaborator network and my research profile, as well as my increased productivity, will positively affect the way my portfolio is viewed. The MSRI fellowship has been instrumental in all of those factors.</p> <p><b>Please comment on your experience with the online format of the program. Were there any surprising benefits from an online meeting? What were the most important factors that were missing compared to an in person meeting? How could the experience be improved?</b></p> <p>The online format was tough. I don't think I can say that the online meetings had any advantages over in-person ones (with the important exception, of course, of the fact that online meetings were safe and in-person meetings were not, during most of the time of this program). For example, being able to write on the same whiteboard or chalkboard would have been really helpful in back-and-forth exchanges of ideas. MSRI was kind enough to pay for me to purchase a tablet, which I used several times when talking with one of my collaborators (during these meetings, it was nice to use the JamBoard whiteboard, to which I had access through MSRI), but my other collaborators either did not have a tablet or were not comfortable enough with the technology for us to collaborate seamlessly. I commend MSRI for all the efforts it made to make the online experience as beneficial as possible, and I don't think it could have much differently in order to improve the experience. However, the online format just wasn't the same as in-person collaborations would have been.</p>
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**Miller, Evan**

**Name: Evan Miller**

Year of Ph.D: 2019

Institution of Ph.D.: University of Toronto

Dissertation title: The Navier-Stokes Strain Equation with Applications to Enstrophy Growth and Global Regularity

Ph.D. advisor: Robert McCann

Mentor while at MSRI: Jean-Yves Chemin

Pre-MSRI Institution: McMaster University

Position at that institution: Postdoc

Mentor (if applicable): Eric Sawyer

Post-MSRI institution: University of British Columbia

Position: PIMS postdoc

Anticipated length (or specify if tenure-track): 2 years

Mentor (if applicable): Tai-Peng Tsai and Stephen Gustafson

**Postdoctoral fellow's comments:**

During this semester I have worked with Jean-Yves Chemin, focused to a large extent on an equation for the horizontal velocity in incompressible fluid dynamics that was derived as an asymptotic approximation of almost two dimensional solutions of the three dimensional Euler or Navier-Stokes equations. We have considered this equation in both the perturbative and non-perturbative regime. For the viscous horizontal velocity equation, there is global regularity in the perturbative regime, but it appears that there is likely finite-time blowup in the non-perturbative regime. This is very interesting, and could serve as a possible model for finite-time blowup for the full 3D Navier-Stokes equation. This research is a work in progress, but I expect that a high quality paper will come out of this work in the next several months. During this semester I have also continued to work on the role of the strain in the Navier-Stokes regularity problem. I strengthened the results in my preprint "Finite-time blowup for a Navier-Stokes model equation for the self-amplification of strain", and posted an updated version of this preprint on arXiv and submitted this paper to Analysis & PDE. I have also been putting together further work on the interaction of strain and vorticity for the evolution of strain that is currently a work-in-progress, but should be posted on the arXiv and submitted in the next couple of months.

During the semester, I helped organize the postdoc talks in the various seminars, ensuring that every postdoc was able to give a talk in one of the seminars. I also refereed several articles.

**Did you find your experience at MSRI beneficial? Why or why not?**

Yes, my experience at MSRI was very beneficial. Working with Jean-Yves Chemin has been wonderful, and I think we have been



able to make some real progress on a very interesting problem. The seminars have also been a great opportunity to learn so much about different aspects of fluid mechanics that aren't my area of expertise, and to deepen my understanding of my own area, Navier-Stokes analysis. Finally, the institute itself is a wonderful and inspiring place to work. I look forward to returning in the Summer of 2023.

**Do you feel your fellowship has helped (or will help) you with finding a future position? If so, in what way?**

I definitely think that my postdoctoral fellowship will help me find a tenure track position. The chance to talk in one of the seminars with many of the leading experts in the world was a great opportunity to make the fluid dynamics community more aware of my research. My research has benefitted from the program, and the professional development events were also very helpful. And, of course, the MSRI postdoctoral fellowships are quite prestigious, so it will certainly be beneficial to have that on my CV when applying for tenure track positions.

**Please comment on your experience with the online format of the program.**

The online format meant wider participation in the seminars, which was great, and meant the postdocs were able to speak about our research to an even larger audience than would be possible otherwise. The zoom seminars were run very well, and I felt like this format worked well for the seminars. The tea rooms and postdoc social hours also helped to combat isolation. The biggest loss was the inability to discuss mathematics in detail without having to schedule an appointment. One of the great things about conferences is the ability to catch someone in the hallways after a talk, and just go over to a chalk board and start talking about a problem. The zoom meetings with my mentor went well, but for the little questions that might lead somewhere or might not, it is much more intimidating to email a speaker (that I may not have met in person) to set up a zoom appointment to talk about the problem, than to just discuss informally during the breaks, so this sort of interaction didn't really happen.

#### IV. 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.

<b>Member Name</b>	<b>Paper Titles</b>	<b>Co-author(s)</b>	<b>Paper Status</b>
David Corwin	Selmer Varieties for Elliptic Motives	None	Rough/Draft
Trevor Leslie	TBD	Hajer Bahouri, Galina Perelman	Rough/Draft
Evan Miller	Finite-time blowup for the inviscid horizontal velocity equation	Jean-Yves Chemin	Rough/Draft
	A Helmholtz-type decomposition for the space of symmetric matrices	Eric Sawyer	Working Notes
	Finite-time blowup for a Navier—Stokes model equation for the self-amplification of strain	None	Submitted
	On the interaction of strain and vorticity for the Navier—Stokes equation	None	Working Notes
Nicholas Miller	Azumaya algebras and once punctured torus bundles	None	Rough/Draft