MSRI's ADJOINT: African Diaspora Joint Mathematics Workshop

Hélène Barcelo and Edray Herber Goins

Figure 1. Participants in ADJOINT 2020 on Friday, June 26, 2020, together with Hélène Barcelo, MSRI's Deputy Director. Top row: Naomi Cameron, Hélène Barcelo, Ryan Hynd, Donald King, Timothy Myers. Second row: Romeo Awi, Douglas Mupasiri, Lofti Hermi, Lawrence Udeigwe, Terrance Pendleton. Third row: Bonita Saunders, Tepper Gill, Rachel Vincent-Finley, Eddy Kwessi, Craig Sutton. Fourth row: Sherry Scott, Kamal Barley, Henok Mawi, Talitha Washington, Ron Buckmire. Bottom row: Sean Brooks, Dennis Ikpe, Abba Gumel, Keisha Cook.

ADJOINT is a new program intended primarily for African-American mathematicians and statisticians. It is designed to catalyze research collaborations and provide support for

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Communicated by Notices Associate Editor Robin T. Wilson.

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DOI: <https://doi.org/10.1090/noti2212>

conference participation; its specific goals include increasing the visibility of its participants and developing a sense of community among African-American researchers. The program is structured with an introductory two-week meeting at MSRI which provides opportunities for in-person research work in small groups with project leaders on various topics. The program continues throughout the following year via both online meetings and visits to team members' institutions. ADJOINT is funded by the National Science Foundation (DMS-1915954 and DMS-2016406), the National Security Agency (H98230-20-1-0015), and the Sloan Foundation (G-2020-12602).

Why ADJOINT?

In February 2019, the *New York Times* published two articles focused on the dearth of Black faculty in the mathematical sciences [3, 4]. As observed in the second of the two articles: "According to the American Mathematical Society, there are 1,769 tenured mathematicians at the math departments of the 50 United States universities that produce the most math Ph.D.s. No one tallies the number of black mathematicians in those departments, but as best I can tell, there are 13. That comes to seven-tenths of 1 percent of the total—perhaps as far as any job classification gets from accurately reflecting the share of black Americans in the general adult population, which stands at 13 percent."

Indeed, these low numbers are well known to the mathematical community. The Conference Board of Mathematical Sciences (CBMS) Fall 2015 Statistical Abstract of Undergraduate Programs in the Mathematical Sciences in the United States [1] reported that African-Americans make up 1%, 3%, and 3%, respectively, of all mathematical sciences faculty in doctoral-level, masters-level, and

bachelors-level four-year mathematics departments. Even with the low numbers of African-American faculty in mathematics, there is concern over how to keep these faculty actively engaged in research. A report on higher education from Hanover Research [5, pg. 10] observes that “Bland, et al. [2] conclude that, ‘when individual faculty’s research productivity is the goal, nothing substitutes for’ four factors in particular: (1) recruiting faculty with a passion for research; (2) providing them with formal mentoring programs; (3) facilitating their networks; and (4) providing time for them to do research.”

The underlying goal of the ADJOINT program is to increase the number, productivity, and visibility of African-American mathematical and statistical researchers. ADJOINT aims to address this issue of underrepresentation by increasing individual faculty research productivity through organized collaborative research groups and formal mentorship opportunities. The ADJOINT program takes its inspiration from MSRI’s very successful Summer Research in Mathematics (SRiM) and MSRI-UP programs. The SRiM program (formerly the Summer Research Program for Women in Mathematics, or SWiM) supports groups of researchers, predominantly women, to advance and complete already existing projects. MSRI’s Undergraduate Program (MSRI-UP) is a six-week REU program whose goal is to identify talented students (18 per summer), especially those from groups underrepresented in math, and introduce them to research in mathematics.

The initial idea for ADJOINT grew out of conversations between four individuals in 2018. That year, Hélène Barcelo was the Acting Director of MSRI, Edray Goins was President of the National Association of Mathematicians (NAM), Michael Singer (North Carolina State University) was Assistant Director of MSRI, and Robin Wilson (California State Polytechnic University at Pomona) was the chair of MSRI’s Human Resources Advisory Committee (HRAC). The four of us worked together to formulate the program and write the initial NSF grant proposal. We chose the title “African Diaspora Joint Mathematics Workshop” in recognition of the inhomogeneity of the Black experience: the term “African Diaspora” describes the dispersion of people from Africa during the Transatlantic Slave Trades.

Structure of ADJOINT

There are three groups of individuals involved with ADJOINT: program participants, research leaders, and program directors.

Program participants. Each year, up to twenty researchers participate in the program. The participants are mainly junior mathematicians that initially spend two weeks in residence at MSRI. During that period, participants spend most of their time engaged in research with team members

under the guidance of the research leaders. The teams are formed prior to the MSRI residency. In addition, professional development workshops and a weekly colloquium series are offered. An early milestone in the program is the research project presentations on Friday afternoons. After this initial two weeks, the researchers remain active during the academic year via virtual meetings as well as visits to team members’ institutions; members are also encouraged to attend and present their work at national and international conferences. The research leaders and program directors continue to support the participants throughout the years.

Participants must be either US citizens or permanent residents, must possess a PhD in the mathematical or statistical sciences, and must be employed at a US institution. Applicants are asked to submit: (1) a cover letter specifying which of the offered research projects the applicant wishes to be part of; (2) a curriculum vitae; (3) a personal statement, no longer than one page, addressing how participation will contribute to the goals of the program; and (4) a research statement, no longer than two pages, describing current research interests, and relevant past research activities, and how they relate to the project of greatest interest.

While the participants do not need to be African-American, an applicant’s potential positive impact on the careers of African-Americans in the mathematical sciences is an important factor in the final selection. We consider whether participation would help with promotion and tenure; provide networking opportunities; and encourage the participant to remain active in research. We are especially interested in applicants who are employed at Historically Black Colleges and Universities (HBCUs).

Research leaders. Each year, the ADJOINT directors select five research leaders who are respected African-American mathematicians with well-established research programs. Each will lead a group of up to five participants during the two-week part of the program held at MSRI, as well as afterward.

The research leaders and participants will each receive funding for two weeks of lodging, round trip travel to MSRI, and funding to travel to conferences or to team members’ institutions to continue research collaborations.

Program directors. ADJOINT is administered by five program directors: Edray Goins (Pomona College) as the lead director, Caleb Ashley (University of Michigan at Ann Arbor), Naiomi Cameron (Spelman College), Jacqueline Hughes-Oliver (North Carolina State University), and Anisah Nu’Man (Spelman College).

The program directors recruit the five research leaders and select the twenty participants. Each summer only one of the directors will be in residence at MSRI during the two

Figure 2. Derek Young (left), Chassidy Bozeman, Michael Young, Rachel Kirsch, and Theodore Molla.

intense weeks of research.

The onsite program directors follow and support their cohort for the next five years. Additionally, they oversee the program, provide support for the research teams, and lead participants in professional enhancement activities that include discussions on best practices for job applications, pursuing promotion and tenure, disseminating research, grant writing, and more.

The onsite director for 2020 was Naomi Cameron, and the onsite director for 2021 will be Jacqueline Hughes-Oliver.

ADJOINT 2019 – Pilot Program

We held a pilot program onsite at MSRI in the summer of 2019; it was funded by the NSF (DMS-1915954). We began small, working with a total of fifteen researchers divided into three working groups. All teams were predominantly comprised of African-American mathematicians at various stages in their careers. We were not able to get all three groups to come to MSRI at the same time, so these groups met at different times for varying lengths.

Graph theory. From June 10–21, 2019, Michael Young (Iowa State University) led a research project in graph theory titled *Problems on Tournaments*. The participants were Chassidy Bozeman (Mount Holyoke College), Rachel Kirsch (London School of Economics), Theodore Molla (University of South Florida), and Derek Young (Mount Holyoke College). (See Figure 2.)

Young described the project as follows. A tournament T is a rebel if the set of domination numbers of all tournaments that do not contain T is bounded from above. Chudnovsky, Kim, Liu, Seymour, and Thomasse asked if the seven-vertex Paley tournament is a rebel and, more generally, if a similar statement holds for every poset

Figure 3. Caleb Ashley (left), Karoline Pershell, Naomi Cameron, Emille Lawrence, and Edray Goins.

tournament. They proved that every tournament that avoids a different tournament on seven vertices has bounded domination number. This research team has been working on determining what other tournaments are rebels and extending the definitions and results to determine what directed graphs are (or are not) rebels. The team is also exploring a conjecture of Mycroft and Naia who ask if, for sufficiently large d , every outbranching balanced binary tree on $n = 2^{d+1} - 1$ vertices is contained in every tournament on n vertices. The group seeks to explore and prove results for specific trees and values of n .

Number theory. From July 8–19, 2019, Edray Herber Goins (Pomona College) led a research project in number theory titled *Compositions of Belyi Maps and their Monodromy Groups*. The participants were Caleb Ashley (University of Michigan), Naomi Cameron (Spelman College), Emille Davie Lawrence (University of San Francisco), Theo McKenzie (University of California at Berkeley), and Karoline Pershell (Association for Women in Mathematics¹ / Service Robotics and Technologies). (See Figure 3.)

Goins described the project as follows. This group's goal was to understand the extended monodromy group $\text{ExtMon}(\beta)$ by two different methods: (i) geometrically, via surjections $\Delta(\beta \circ \gamma) \twoheadrightarrow \Delta(\beta)$ on the dessin d'enfants, and (ii) topologically, via surjections $\text{Mon}(\beta \circ \gamma) \twoheadrightarrow \text{Mon}(\beta)$ on the monodromy groups. The group spent the first week of their visit reviewing Belyi maps, dessin d'enfants, monodromy groups, Naomi Cameron's previous work, and Jacob Bond's previous work. They spent the second week attempting to understand the extending patterns for the specific Belyi map $\beta(z) = -(z-1)^2/(4z)$ by considering the family of dynamical Belyi maps $\gamma(z) = z^n$ for

¹Affiliation as of July 2019.

Figure 4. S. James Gates (left), Caroline Klivans, Kevin Iga, and Vincent Rodgers.

natural numbers n . The group had a follow-up meeting at Pomona College from December 14–17, 2019, but further plans to meet in person are on hold due to the COVID-19 pandemic.

Physics and combinatorics. From July 22–26, 2019, Sylvester James Gates, Jr. (Brown University) led a research project in mathematical physics titled *Mathematical Adinkra Symbols: From Physics to Mathematics Investigations across Algebraic Topology and Graph Theory*. The participants were Kevin Iga (Pepperdine University), Caroline Klivans (Brown University), and Vincent Rodgers (University of Iowa). (See Figure 4.)

Gates described the project as follows. In 2005, two theoretical physicists, Michael Faux and S. James Gates, Jr., proposed a type of graph (now known as “Adinkras”) that had apparently not appeared previously in the mathematical literature. Faux and Gates hoped these graphs could be useful in formulating new pathways to solving problems in theoretical/mathematical physics that lie at the foundation of string theory and that certain problems would be illuminated by this new approach. It was viewed as a possible new tool to unravel long-unsolved representation theory problems in the area of supersymmetry. Instead, Adinkras were discovered to be related to a raft of mathematical subjects: (1) Coxeter groups, (2) error-correcting codes, (3) Grothendieck’s “dessin d’enfant,” (4) Beylī pairs, (5) Cimasoni-Reshetikhin dimer models on Riemann surfaces, (6) Donagi-Witten parabolic structure/ramified coverings of super Riemann surface, (7) Morse divisors, (8) Fuchsian uniformization, (9) elliptic curves, and (10) Schur functions. An apparent breakthrough happened at MSRI during the ADJOINT program as the first glimmer of connection was made between the works of Prof. Caroline Klivans and the

“permutahedron” concept she studies in Coxeter groups and the valise Adinkra concept which Prof. Gates investigates. A main deliverable from this study should be a book that Prof. Kevin Iga of Pepperdine will publish to make the development of this young topic accessible to the mathematical community.

Workshop feedback. We had a good balance of participants for this pilot program. Of the 15 participants, nine were men while six were women; one identified as Asian, three as White, and 11 as African-American.

The exit surveys of the pilot program were quite positive. One of the participants commented: “It was great working with other African-Americans. However, for me the best part about the program is that more African-Americans will be writing papers together and presenting to the math community. [ADJOINT] can make a direct impact on the number of research papers authored and conference presentations given by African-Americans. That is a huge positive.” Another said: “I felt more comfortable working with this group more than any other research group that I have worked with.” A third remarked: “I felt like my voice was respected. This almost never happens in other research collaborations. In fact, it’s hard to have research collaborations because people don’t take me seriously.”

ADJOINT 2020

We were inspired by the positive feedback, and decided to expand the program. The first official ADJOINT took place from June 15–26, 2020; it was funded by NSF (DMS-2016406), NSA (H98230-20-1-0015), and the Sloan Foundation (G-2020-12602).

We had five research leaders and eighteen program participants. The onsite program director was Naiomi Cameron (Spelman College). Due to the outbreak of COVID-19, we decided to hold the program virtually using Zoom. Each of the research leaders and program participants was sent an iPad Pro 12.9” along with Smart Keyboard Folio and an Apple Pencil. We used Google’s Jamboard as a primary way to communicate via a virtual whiteboard.

Unfortunately our balance of participants was not quite what we had hoped for. Of the 23 participants, 18 were men but only five were women. Still, 22 identified as African-American and one as White. Seven were faculty at HBCUs (Coppin State University, Hampton University, Howard University, and Southern University and A&M College).

Mathematical physics. Tepper Gill (Howard University) led a research project in mathematical physics titled *Analysis, Partial Differential Equations, and Mathematical Physics*. The participants were Eddy Kwessi (Trinity University), Douglas Mupasiri (University of Northern Iowa), and

Figure 5. Tepper Gill (top left), Eddy Kwessi, Douglas Mupasiri (bottom left), and Timothy Myers.

Figure 6. Abba Gumel (top left), Talitha Washington, Lawrence Udeigwe; Sherry Scott (bottom left), Keisha Cook, and Kamal Barley.

Timothy Myers (Howard University). (See Figure 5.)

Gill described the project as follows. The center of mass for this research is a new class of separable Banach spaces KS^p , $1 \leq p \leq \infty$, which contains each corresponding L^p space as a dense continuous embedding. These spaces are interesting because they contain the HK-integrable functions and the space of distributions. The HK-integral is easy to understand, extends the Lebesgue integral, and integrates nonabsolutely integrable functions. The spaces generate an arena for a number of interesting research topics in analysis, partial differential equations, and mathematical physics.

Mathematical biology. Abba Gumel (Arizona State University) led a research project in mathematical biology titled *Mathematics of the Transmission Dynamics and Control of the 2019 Novel Coronavirus*. The participants were Kamal Barley (Stony Brook University), Keisha Cook (Tulane University), Sherry Scott (Milwaukee School of Engineering), Lawrence Udeigwe (Manhattan College), and Talitha Washington (Howard University / National Science Foundation). (See Figure 6.)

Gumel described the project as follows. The world is currently facing a devastating pandemic of a novel Coronavirus (COVID-19), which started as an outbreak of pneumonia of unknown cause in Wuhan, China, in

Figure 7. Terrance Pendleton (top left), Henok Mawi, Ryan Hynd; Romeo Awi (bottom left) and Dennis Ikpe.

December of 2019. As of April 26, 2020, COVID-19 (caused by the novel SARS-CoV-2 coronavirus) has spread to over 210 countries and territories, causing about three million infections and 207,000 deaths. In the absence of a safe and effective vaccine against COVID-19, and safe and approved antivirals, control and mitigation efforts are focused on the use of nonpharmaceutical interventions, such as social distancing, quarantine, aggressive containment (i.e., rapid detection, isolation, and contact-tracing of confirmed cases), use of face masks in public, etc. The purpose of this project is to use mathematical modeling approaches and rigorous analysis, coupled with data analytics, to assess the population-level impact of various nonpharmaceutical interventions on controlling and mitigating the burden of the pandemic. In particular, the models we are working on take the form of deterministic (autonomous and nonautonomous) systems of nonlinear differential equations. The project involves the rigorous analysis of the models (using theories and techniques from nonlinear dynamical systems, particularly bifurcation theory) to gain insight into their dynamical features and obtain epidemiological thresholds, in parameter space, that govern the persistence or effective control (elimination) of the pandemic. In addition, statistical tools are being used to estimate the parameters of the models, as well as to fit the models with available data and carry out uncertainty and sensitivity analyses.

Analysis. Ryan Hynd (University of Pennsylvania) led two research projects in analysis titled *Approximating Nash Equilibria* and *A Time Optimal Control for Compartmental Models in Epidemiology*. The participants were Romeo Awi (Hampden University), Dennis Ikpe (Michigan State University), Henok Mawi (Howard University), and Terrance Pendleton (Drake University). (See Figure 7.)

Hynd described the first of his two projects as follows. The notion of a Nash equilibrium is an important concept in the theory of noncooperative games. It is informally described as a collective strategy assumed by several players in which no player can decrease her cost by changing her individual strategy. In terms of mathematics, the collective strategy set can be modeled as a

Cartesian product $X = X_1 \times \cdots \times X_N$, where each X_i represents the possible strategies of the i th player. If $f_1, \dots, f_N : X \rightarrow \mathbb{R}$ represent the cost functions of the respective players, $x \in X$ is a Nash equilibrium provided $f_i(x) \leq f_i(x_1, \dots, x_{i-1}, y_i, x_{i+1}, \dots, x_N)$ for all $y_i \in X_i$ and $i = 1, \dots, N$. Under appropriate continuity and compactness assumptions, it is known that there is a Nash equilibrium. This is typically proved with an analog of Brouwer's fixed point theorem. As a result, this existence result is non-constructive. Nevertheless, we are interested in identifying conditions on $f_1, \dots, f_N$ and X such that there is a Nash equilibrium which can be approximated by a *constructive* method.

Hynd described the second of his two projects as follows. The SIR model is perhaps the best-known epidemiology model. It predicts how three compartments of the total population evolve in time. We consider a variant of this model which involves a vaccination rate $r : [0, \infty) \rightarrow [0, 1]$. Namely, we study the system of differential equations

$$\begin{aligned}\dot{S} &= -\beta SI - rS, \\ \dot{I} &= \beta SI - \gamma I, \\ \dot{R} &= \gamma I,\end{aligned}$$

where $S, I, R : [0, \infty) \rightarrow \mathbb{R}$ represent the susceptible, infected, and recovered compartments of a total population of finite size. Here β and γ are the respective infected and recovery rates per unit time and r represents a controlled vaccination rate. The problem we have been studying is to characterize the vaccination rate which minimizes the time in which the infected population falls below a given threshold $\mu > 0$, that is, we seek to characterize r such that it minimizes the eradication time $\min\{t \geq 0 : I(t) \leq \mu\}$.

Computational mathematics. Bonita V. Saunders (National Institute of Standards and Technology) led a research project in computational mathematics titled *Validated Numerical Computations of Mathematical Functions*. The participants were Sean Brooks (Coppin State University), Ron Buckmire (Occidental College), Opel Jones (Towson University), and Rachel Vincent-Finley (Southern University and A&M College). (See Figure 8.)

Saunders described the project as follows. During the late 1930s, 40s, and 50s accurate tables of function values were calculated by human “computers” to facilitate the evaluation of functions by interpolation. In addition to logarithmic and trigonometric functions, these reference tables included values for Gamma, Legendre, Jacobian, Bessel, Airy, and other high-level or “special” functions important for applied and physical applications. The advent of reliable computing machines, computer algebra systems, and computational packages diminished the need for such reference tables, but today’s researchers and

Figure 8. Sean Brooks (top left), Bonita Saunders; Rachel Vincent-Finley (bottom left), and Ron Buckmire.

Figure 9. Craig Sutton (top left), Lotfi Hermi, and Donald King (bottom).

software developers still need a way to confirm the accuracy of numerical codes that compute mathematical function values. Project participants were introduced to the field of validated computations of special mathematical functions, which is the development of codes that compute certifiably accurate function values that can be used to test the accuracy of values produced by personal, commercial, or publicly available codes.

Differential geometry. Craig Sutton (Dartmouth College) led a research project in differential geometry titled *Explorations in Inverse Spectral Geometry*. The participants were Lotfi Hermi (Florida International University) and Donald King (Northeastern University). (See Figure 9.)

Sutton described the project as follows. Inverse spectral geometry is the study of the relationship between the *spectrum* of a closed Riemannian manifold—i.e., the sequence of eigenvalues (counting multiplicities) of the associated Laplace-Beltrami operator—and its underlying geometry. Two manifolds are said to be isospectral if their spectra agree and a geometric property is said to be *audible* or *spectrally determined* if it is encoded in the spectrum. The spectrum is known to encode the dimension, volume,

and total scalar curvature of a manifold; however, the literature contains numerous examples which demonstrate the spectrum does not completely determine the geometry of the underlying space. Nevertheless, it is expected that certain natural classes of Riemannian manifolds are characterized by their spectra. For example, it is widely believed that the round n -sphere is uniquely characterized by its spectrum; however, to date, this has only been proven for round spheres of dimension at most six. Our research group is working on problems motivated by the following questions. (1) To what extent is the length spectrum of a manifold encoded in its Laplace spectrum? (2) Is the local geometry of a low-dimensional manifold encoded in its spectrum? (3) How are the covering spectrum of a Riemann surface and its Laplace spectrum related?

Community building activities. Each weekday for the two weeks, the research groups were encouraged to work together over Zoom. The entire program came together as a whole several times each week to help build community. We had lunch together every day from 1:00 p.m.–2:00 p.m. EST; there were lunch discussions on “Social Media for Work Productivity” on Wednesday, June 17, 2020, on “Managing Work/Life/Service Loads” on Monday, June 22, 2020, and on “Institutional Impact of COVID” on Thursday, June 25, 2020. We also had three workshops in the afternoon from 2:00–3:00 p.m. EST: a Grant Workshop on Tuesday, June 16, 2020, a Tenure/Promotion Workshop on Tuesday, June 23, 2020, and a Marketability/Leadership Workshop on Wednesday, June 24, 2020.

ADJOINT 2021

The next program will take place at MSRI from June 21 through July 2, 2021; the onsite program director will be Jacqueline Hughes-Oliver (North Carolina State University). We have four research leaders lined up so far.

Algebraic geometry. Danny Krashen (Rutgers University) will lead a research project in algebraic geometry titled *Adventures in Constructive Galois Theory*. He describes the project as follows. Understanding Galois extensions of fields is a central problem in algebra, with a number of open questions, accessible at many levels. In this project we will explore “explicit inverse Galois theory,” which tries to understand which groups arise as Galois groups for a given field, and how. Our goal will be to use these constructive approaches to understand richer algebraic structures and properties that collections of Galois extensions exhibit as a whole.

Geometric group theory. Nathan Broaddus (Ohio State University) will lead a research project in geometric group theory titled *Steinberg Modules of Braid Groups*. He describes the project as follows. Many important groups of

interest in topology are duality groups. As such they have an associated group cohomological object which we call the “Steinberg module” of the group. We will begin with an introduction to the braid group and discuss a number of elementary descriptions of its Steinberg module. Our first research goal will be to unify as many of these disparate descriptions as possible.

Biostatistics. Emma K. T. Benn (Mount Sinai University) will lead a project in biostatistics titled *Racial/Ethnic Disparities in Health: Applying a More Nuanced Inferential Framework*. She describes the project as follows. Reducing and eliminating health disparities is of utmost concern for many public health and biomedical researchers and has been a stated goal for Healthy People 2000, 2010, and 2020. However, when it comes to racial disparities in health, researchers have done well at describing differences, but have often struggled to identify mutable targets for intervention. This problem exists for a host of reasons, including the complex contextual factors surrounding racial disparities; however, this may also stem from the way in which we operationalize race in research. For the proposed project, we will first explore the operationalization of race as a “cause” when examining racial disparities in health based on multidisciplinary discourse around this topic from statisticians informed by the potential outcomes framework, epidemiologists, clinical investigators, and others. Subsequently, we will critically scrutinize the traditional approaches to investigating disparities in health and apply a more nuanced inferential, rather than descriptive, approach to the statistical analysis of real-world biomedical data with an underlying objective to find efficacious interventions for eradicating health disparities.

Operations research. Julie Ivy (North Carolina State University) will lead a project in operations research titled *Using Decision Modeling to Personalize Policy in Complex Human-Centered Problems*. She describes the project as follows. The COVID-19 pandemic highlights the importance of sequential decision making under conditions of uncertainty, learning as the future evolves, and effectively using data to inform decision making. The pandemic further highlights the significant role that mathematical modeling can and should play in addressing complex human-centered problems. This research project will consider these types of problems from a systems modeling perspective. The focus of this project will be decision making under conditions of uncertainty with the goal of modeling complex interactions and quantitatively capturing the impact of different factors, objectives, system dynamics, intervention options, and policies on outcomes with the goal of improving decision quality.

What's Next?

We plan to continue with ADJOINT on a variety of fronts in 2021. In particular, there was a special session on Saturday, January 9, 2021, at the Joint Mathematics Meetings titled "ADJOINT (African Diaspora Joint Mathematics Workshop) Research Showcase." This gave past participants of ADJOINT the opportunity to present their research, and exposed prospective participants to a preview of future workshops.

For more information about ADJOINT, please visit <https://www.msri.org/web/msri/scientific/adjoint>.

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