

**RTG: electronic Computational Homotopy Theory Research
Community
Year 3 report**

FUNDED PARTICIPANTS

Funded participants in Year 3 were:

- David Mehrle, Kentucky, postdoctoral researcher. The project paid half of his academic year salary and also provided summer support.
- Jack Carlisle, Notre Dame, postdoctoral researcher. The project paid half of his academic year salary and also provided summer support.
- Sarah Petersen, Colorado, postdoctoral researcher. The project paid half of her academic year salary.
- Scotty Tilton, UC San Diego, graduate student. The project fully supported him during the academic year, including tuition and stipend.
- Hassan Abdallah, Wayne State, graduate student. The project fully supported him during the academic year, including tuition and stipend.
- Millie Rose, Kentucky, graduate student. The project fully supported her during the academic year, including tuition and stipend.

RESEARCH ACTIVITIES

Reading seminars. We hosted two research-oriented reading seminars. The topics were quadratic curve counting and homotopical combinatorics. The participants consisted of a mixture of graduate students, postdoctoral researchers, and tenure-track/tenured faculty. About half of the participants were located at U.S. institutions.

The organizers selected participants to give weekly talks on specific topics. We have had great success with this model of having participants take turns giving presentations.

Quadratic curve counting seminar. The seminar was organized by Thomas Brazelton (Harvard University) and Sabrina Pauli (Darmstadt), assisted by graduate student Jackson Morris (University of Washington). The seminar attracted approximately 20 participants.

Homotopical combinatorics seminar. The seminar was organized by co-PI JD Quigley (University of Virginia) and Scott Balchin (Queen's University Belfast), assisted by graduate student Millie Rose (University of Kentucky). The seminar attracted approximately 30 participants.

Research seminar. We held a regular research seminar that met once per month for two talks. The seminar was managed by Guchuan Li (Peking), co-PI J.D. Quigley (Virginia), funded postdoctoral researcher Jack Carlisle (Notre Dame), funded graduate student Scotty Tilton (UC San Diego), and funded graduate student Hassan Abdallah (Wayne State).

The 16 speakers were evenly split between postdoctoral researchers and tenure-track/tenured faculty. Half of the speakers were located in the United States, with additional speakers from China, Denmark, Germany, the Netherlands, and the United Kingdom.

Video recordings of most seminars are available to the public. Analytics suggest that the videos earn a significant on-going viewership.

Mini-courses. Guchuan Li (Peking), funded postdoctoral researcher David Mehrle (Kentucky), and funded postdoctoral researcher Sarah Petersen (Colorado) organized two mini-courses. Weinan Lin (Fudan), Guozhen Wang (Fudan), and Zhouli Xu (UCLA) gave a four-part mini-course in December 2024 about their study of the Adams spectral sequence and the fate of the 126-dimensional Kervaire element. Nat Stapleton (Kentucky) gave a five-part mini-course in May 2025 about power operations and global algebra. Video recordings and lecture notes for both mini-courses are available to the public. Analytics suggest that the videos earn a significant on-going viewership.

INSTRUCTIONAL ACTIVITIES

We offered four synchronous online courses in the 2024–2025 academic year. Each student was expected to participate fully in the course, just as if it were an in-person course at the student’s home institution. Each student earned a formal final grade at the end of the semester. These grades were reported directly to the students’ home institution advisors.

We advertised the courses through a variety of channels, including:

- Subject-specific mailing lists such as `algtop-1`.
- The American Mathematical Society’s Mathematical Opportunities webpage:
www.ams.org/opportunities.

Duality and spectra. Funded postdoctoral research Sarah Petersen taught a course on duality and spectra with the assistance of funded graduate student Millie Rose. It was intended for advanced graduate students who were already familiar with stable homotopy theory. Eleven students enrolled in the course, of which seven were located in the United States. One enrolled student was a tenure-track faculty member; the rest were graduate students. Students were expected to attend class meetings, including the discussion portions, and to complete written portfolio.

Stable homotopy theory. Funded postdoctoral researcher David Mehrle taught a course on stable homotopy theory with the assistance of funded graduate student Scotty Tilton. It was intended for mid-career graduate students who were already familiar with graduate-level algebraic topology. Sixteen graduate students enrolled in the course, of which thirteen were located in the United States. Students took turns giving presentations on the topic of the week. The presentations were based on outlines provided by

the instructors. Students also worked each week in small groups on problem sets.

The same course was previously offered in Winter 2024. The instructor made minor improvements in the second iteration. This course is eCHT's most successful instructional activity. In both iterations, the applicant pool was particularly strong. There is clearly demonstrated demand for a yearly offering on a permanent basis.

The instructor David Mehrle will work with the PI Dan Isaksen to make the course materials available to the public. The course is a valuable resource to widen access to stable homotopy theory. More generally, the course provides a viable model for courses on a variety of topics that are intended for mid-career graduate students. There is great demand for such courses from students because many institutions are unable to offer low-enrollment courses for advanced graduate students. Advanced graduate students are very mature students, and they take ownership for their own learning. This maturity overcomes many of the deficiencies of online instruction.

Kan seminar. Funded postdoctoral researcher Jack Carlisle led Kan seminars in Fall 2024 and Winter 2025, with the assistance of funded graduate students Hassan Abdallah and Scotty Tilton.

In total, twenty-five graduate students participated in the seminars. Each student gave a presentation about a classic paper in algebraic topology. Half of the students were enrolled at institutions in the United States. The seminar is an electronic version of the well-known Kan seminar at MIT.

eCHT has offered online Kan seminars every year since 2019. They have been one of our most popular activities. They are well-suited for graduate students who are making the difficult transition from coursework to independent study. We plan to offer Kan seminars yearly in the future, provided that we can identify experienced researchers who are willing to provide leadership for the seminars.

REU

This section of the report summarizes activities that were carried at the end of Year 2, after the previous annual report was submitted.

The Summer 2024 REU was led by Irina Bobkova (Texas A&M) assisted by Jack Carlisle (Notre Dame) and Scotty Tilton (UCSD). The students participated for five hours per day for six weeks. Students engaged in a variety of activities during work hours, including lecture, small group work, and individual work. Students met in various combinations with the REU staff. One publication [BCF⁺24] resulted from the project.

The PI Dan Isaksen handled all of the administrative aspects of the REU. This allowed Bobkova, Carlisle, and Tilton to focus solely on the scientific aspects of the REU.

Based on our experience from the 2023 REU, we narrowed our advertising efforts to the most effective channels:

- The American Mathematical Society: www.ams.org/opportunities
- The Institute for Broadening Participation: pathwaystoscience.org
- The Math REU Programs website: www.mathreuprograms.org
- NSF's list of REU Sites: Mathematical Sciences:
www.nsf.gov/crssprgm/reu/list_result.jsp?unitid=5044

Overall, we consider the REU advertising to be a success. We received a large, varied applicant pool of more than 100 applications. All six of our first offers were accepted. This is evidence that online REUs are an attractive option for some undergraduate students.

The 2024 REU selection process focused narrowly on mathematical criteria. We selected very talented students who already had some genuine interest in topology, as well as some experience in that field. Our results point to the importance of offering both in-person and online REUs to meet the needs of a variety of undergraduate students.

ASSESSMENT

Course and reading seminar evaluations. We conducted a formal evaluation for each course and reading seminar. Participants were invited to provide anonymous feedback. Response rates were appropriately high. Overall, participants were enthusiastic about the experiences. Some participants offered specific suggestions that we intend to act upon in future years.

Annual report. A draft version of this report was circulated amongst the co-PIs and Senior Personnel. Their feedback was incorporated into the final version of this report.

REU assessment. We assessed the Summer 2024 REU at its end through:

- an anonymous evaluation form submitted by the undergraduate participants.
- individual exit interviews between the PI and each undergraduate participant.
- a group debriefing involving all of the leaders of the program.

Overall, both students and leaders were enthusiastic about the experience.

BUDGET AND ADMINISTRATION

The project administration requires cooperation amongst a variety of departments at different institutions, as well as their sponsored programs offices. There was some concern that these complicated interactions could lead to ineffective management. This turned out not to be an issue. Some effort was involved to make sure that all units communicated with each other, but there were no major problems of this nature.

CONDUCT

Unfortunately, many online communities degenerate into unhealthy, negative interactions. We are consciously building a healthy online community. This requires the leaders to take active roles in setting constructive tones. We are pleased with the results of our efforts.

We wrote and posted an official eCHT Code of Conduct:

s.wayne.edu/echt/echt-code-of-conduct.

We offer an online reporting tool, with optional anonymity. We are fortunate that we received no reports.

In the 2022–2023 academic year, one incident was reported verbally to the project director. It was resolved directly between the conflicting parties.

In the 2023–2024 and 2024–2025 academic years, no incidents were reported.

REFERENCES

- [BCF⁺24] Irina Bobkova, Jack Carlisle, Emmett Fitz, Mattie Ji, Peter Kilway, Hillary Kim, Kolton O’Neal, Jacob Schuckman, and Scotty Tilton, *The $E_2^{hC_6}$ -homology of $\mathbb{R}P^2$ and $\mathbb{R}P^2 \wedge \mathbb{C}P^2$* (2024), available at [arXiv:2412.02669](https://arxiv.org/abs/2412.02669).