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Inspire Page

Alexander P. Cassem

Research Interests

Theoretical Physics, cosmological correlators (bootstrap, analyticity, S-matrix, etc.), gravitational effective field theory, analytic S-matrix, large scale structure (EFT), holography (AdS/CFT & dS/QFT), no-go theorems, string theory (swampland, cosmology), gometrical-mathematical physics.

Education

2022-Present **Tufts University, Medford MA**,
Theoretical Physics, Doctor of Philosophy, Completed quantum field theory two, string theory, and quantum field theory 3 (axions) at Harvard. Masters was awarded May 2024 validated *here (LinkedIn)*. GPA: 3.975

2017–2022 **Winona State University, Winona MN**,
Physics and Mathematics, Bachelor of Science, Honors Program Cum Laude, Awarded degree in Physics May 2021. Awarded degree in Mathematics May 2022. GPA in degree: 3.76, Math & Physics: 3.85.

2019 **University of Minnesota, Saint Paul MN**,
Physics, GPA: 3.54.

Honors, Awards, and Grants

October 2025 **Graduate Student Conference Reimbursement Fund**, *Tufts University*.
- Awarded funds to travel and present on results at COSMO '25.

June 2020 & June 2021 **REU Fellowship**, *Lehigh University*.
- Awarded an REU fellowship at Lehigh University for summer of 2020 and summer of 2021.
- Focus both years was on theoretical physics and string theory.

November 2021 **Professional Improvement Funds**, *WSU*.
- I submitted and received partial funding to study quantum cosmology at Winona State.

July 2018–Present **Dean's List**, *WSU & UMn*.
- Consistent honor on Dean's list since July 2018.

August 2018 & Fall 2020 **Ormsin Sornmoonpin Gardiner Physics Scholarship** , *WSU*.
- Awarded the Ormsin Sornmoonpin Gardiner Physics Scholarship for the 2018 and 2020 academic year for performance in academics.

Research Highlights

Ongoing **UV Behavior of 1-Loop Bispectrum**, *Tufts University, Institute of Cosmology, MA, USA*.
- I am working on computing the 3-site 1-loop contribution to the wave function coefficient that translates into the 1-loop constribution to the bispectrum in de Sitter space, and thus for inflation in the UV limit.
- The computation is being done with a combination of new techniques to the cosmological correlator language by using η-regularization for divergent integrals and Baikov representation to re-formulate the Feynman integrals analogous to Schwinger parameterization.

Ongoing **Shapiro Time Delay for Dynamical Chern-Simons Gravity**, *Prof. Mark Hertzberg, Tufts University, Institute of Cosmology, MA, USA*.
- We derive the dispersion relation for dynamical Chern-Simons (dCS) gravity on a gravitational wave background that allows us to derive the Shapiro time delay plus a correction from dCS that gives superluminal velocities, thus violating causality.
- We work out the Shapiro time delay to second order on a gravitational wave background and show that in a specific limit, even at second order general relativity, dCS coupling can not be saved entirely and is still acasual.

Ongoing **Cosmological Bootstrap of Kaluza Klein Gravitons**, *Prof. Soubhik Kumar, Tufts University, Institute of Cosmology, MA, USA*.
- We are bootstrapping the cosmological correlation trispectrum (four-point function) of inflatons exchanging a massive scalar for a specific five dimensional phenomenological model.
- We are also making direct comparisons to known results using in-in correlators to the bootstrap program observing viability and accuracy of the methodologies.

August 2024 **Effective Field Theory of Gravity**, *Prof. Mark Hertzberg, Tufts University, Institute of Cosmology, MA, USA*.
- Compared constraints from causality and solar system bounds on effective field theory (EFT) of general relativity (GR) by computing the 1-loop correction to Newton's potential, and found that solar system measurements constrains EFT of GR by at least 10^7 orders of magnitude more.
- This work has been published in JHEP that can be found *here*.

May 2021–May 2022 **Geometric Flows and The Swampland, REU**, *Prof. Sera Cremonini, Lehigh University, PA, USA*.
- Learned about the string Swampland, and specifically focused research around distance conjectures of moduli spaces.
- Interested in how distance conjectures are related to geometric flows as the moduli evolves under a flow following a geodesic infield theory space, gives a distance conjecture.
- Results implied that each moduli space will have a corresponding geometric flow based upon underlying geometry and geometric picture of Swampland.
- Worked on how a distance conjecture can be found for Kähler moduli using Calabi-Yau flow.

November 2021–May 2022 **An Exploratory Introduction to Quantum Cosmology**, *Prof. Andrew Ferstl, Winona State University, MN, USA*.
- Learned the techniques and previous history of quantum cosmology starting with Wheeler and DeWitt.
- Interested in how quantum cosmology can be used as the grounds for testing specific theories of quantum gravity.

October 2020–May 2021 **Geometrization of Hawking Radiation via Ricci flow**, *Prof. Andrew Ferstl, Winona State University, MN, USA*.
- Learned the techniques of Ricci flow and mathematical formalism behind the flow.
- Interested in how the Ricci Flow behaves under dynamic Einstein manifolds pertaining to black hole metrics.
- Learned advance techniques in Ricci flow and black hole dynamics including black hole thermodynamics, conformal transformations, and singularity theorems.

May 2020–December 2020 **Gauge/Gravity Duality, REU**, *Prof. Sera Cremonini Lehigh University, PA, USA*.
- Learned the basics of the gauge/gravity duality and differential geometry calculations in *Mathematica* during the summer REU.
- In fall 2020, I calculated the geometry at zero temperature for a 5-dimensional system that breaks rotational symmetry in order to calculate the shear viscosity η/s of the system.
- Gained experience in calculating quantities using gauge/gravity duality and how to handle complex systems.

Teaching, Tutoring, and Research Positions

May 2025 - August 2025 **Instructor of Record**, *Tufts University*.
- I taught physics 12 during the summer at Tufts University. Any of the course material and the student's course feedback is available upon request.

January 2024-Present **Research Assistant**, *Tufts University*.
- I have been an RA for Mark Hertzberg working on gravitational effective field theories and constraining them on physical principles.

August 2022-December 2023 **Teaching Assistant**, *Tufts University*.
- I have been a TA for both labs and recitation sections for physics 1/11 & physics 2/12 (first year of algebra & calculus based physics).

August 2021–May 2022 **Master Tutor**, *WSU*.
- In August 2021, I was promoted to a *Master Tutor* for physics and mathematics. With this position, I ran the tutor tasks (tasks that each tutor must complete each week that involve more training on the subject), managing people's performance, and oversaw our influence on social media.

August 2019–May 2021 **Tutor**, *WSU*.
- Since fall semester of 2019, I have been a tutor for physics, mathematics, and some philosophy and psychology courses due to my extra-curricular readings of the subjects.

January 2020–May 2023 **Teaching Assistant**, *WSU*.
- Teaching assistant for the introductory to physics course, calculus based.
- Developed labs, lab exams, and graded labs. Those labs can be found on my website's blog.

January 2022-May 2022 **Senior University**, *WSU*.
- Co-taught a course titled *What are we made of? A Physicist's Perspective*. Course is designed for retirees who want to learn more about physics.

Scientific Literature and Presentations

Presentations & Seminars.
- I presented at COSMO '25 (which can be found *here*) as a parallel speaker.
- Since 2022, I have been presenting to Tufts physics graduate students once a semester for either practice or present new results.
- May 2022, Tufts University: *Geometric flows and the Swampland*.
- I presented at Lehigh's end of REU presentation summer 2021.
- I presented in the first NSF-REU Poster symposium which was October 16th, 2021. The poster for that presentation is found on my website. The symposium was hosted by the University of California, Santa Barbara.
- I presented my work on Ricci flow and Black holes at Winona State, May 2021, at the Ramaley Research Collaboration.
- The following are seminars that I have participated in: Strings 2021, COSMO'21, Workshop on Black Holes, BPS, and Quantum Information Sept.20-24th. I am continuing participant in the International Loop Quantum Gravity Seminar (since July 2021) and the Western Hemisphere Colloquium on Geometry and Physics (since July 2021).
- I currently participate in the following seminars in the Boston area: Harvard's Swampland seminars, Tufts/MIT cosmology seminars, MIT's string/gravity seminars, and Tufts Math department's seminars: the Geometry and topology seminars and the Number theory seminars.

Skills

Languages LaTeX, *Mathematica* including the following subpackages: xAct, xFields, xTras, etc., Python.

Utilities Anaconda, Git, and Jupyter Notebook

Communication English and French (reading, writing, & some fluent speech).

References

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