

# Alexander P. Cassem

## Research Interests

**Theoretical Physics**, Quantum spacetime, classical and quantum cosmology, gravitation, field theory, statistical mechanics, string theory, condensed matter theory with AdS/CFT, and Higgs Phenomenology.

## Education

- 2017–2022 **Winona State University, Winona MN**,  
*Physics and Mathematics*, Bachelor of Science, Honors Program Cum Laude, Awarded degree in Physics May 2021. Expected Mathematics degree in May 2022. GPA in degree: 3.75, Math & Physics: 3.82.
- 2019 **University of Minnesota, Saint Paul MN**,  
*Physics*, Returned to Winona, GPA: 3.54.

## Honors, Awards, and Grants

- June 2020 & June 2021 **REU Fellowship**, *Lehigh University*.  
◦ I was awarded an REU fellowship at Lehigh University for both the 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.  
◦ Grant was given through Professional Improvement Funds (PIF).
- July **Dean's List**, *WSU & UMn*.  
◦ Consistent honor on Dean's list since July 2018.
- 2018–Present **Ormsin Sornmoonpin Gardiner Physics Scholarship**, *WSU*.  
◦ Awarded the Ormsin Sornmoonpin Gardiner Physics Scholarship for the 2018 and 2020 academic year for performance in academics.
- 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

- May 2021–Ongoing **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 in field theory space, gives a distance conjecture.  
◦ Gave the general idea that each moduli space will have a corresponding geometric flow based upon underlying geometry and geometric picture of Swampland.  
◦ Currently working on how a distance conjecture can be found for Kähler moduli using Calabi-Yau flow.
- November 2021–Ongoing **An Exploratory Introduction to Quantum Cosmology**, *Prof. Andrew Ferstl, Winona State University, MN, USA*.  
◦ Currently learning 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– **Gauge/Gravity Duality, REU, Prof. Sera Cremonini Lehigh University, PA, USA.**
- December 2020
- o Learned the basics the gauge/gravity duality and Differential Geometry calculations in *Mathematica* during the Summer REU.
  - o In Fall 2020 term, I am calculating the geometry at zero temperature for a 5-dimensional system that breaks rotational symmetry in order to calculate the shear viscosity of the system.
  - o Gained experience in calculating quantities using gauge/gravity duality, and how to handle more complex systems.
- January 2020–May 2020 **Fermonic Cosmologies in Brans-Dicke Gravity, Prof. Andrew Ferstl, Winona State University, MN, USA.**
- o Found the Friedmann Equations in the context of Brans-Dicke Gravity with a Fermionic Field.
  - o Analyzed the possible solutions towards the Friedmann equations through a general potential.
  - o Found, in correlation to preceding work, that depending on the parameter  $n$ , you find either inflation, or dark energy behavior.
  - o Gained experience working in theoretical physics, and computations in Mathematica.

## Teaching and Tutoring

- August 2019–Present **Master Tutor, WSU.**
- o 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.
  - o Since August 2021, I was hired as an adjunct as a *Master Tutor* for physics and mathematics. With this position, I run the tutor tasks (tasks that each tutor must complete each week that involve more training on the subject), micromanaging people's performance, and recently the overseeing of our influence in social media.
- January 2020–Present **Teaching Assistant, WSU.**
- o I have been a teaching assistant since spring of 2020 for the introductory to physics course, calculus based.
  - o I also have developed labs, lab exams, and graded labs via the supervision of Professor Ferstl. Those labs can be found on my website's blog.
- January 2022–May 2022 **Senior University, WSU.**
- o Starting the spring semester of 2022, I will be sitting in and then teaching a course titled *What are we made of? A Physicist's Perspective*.
  - o The course is designed for graduates in non-scientific fields who want to learn more about physics.

## Scientific Literature and Presentations

### Presentations & Seminars.

- o I presented at Lehigh's end of REU presentation summer 2021.
- o 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.
- o I presented my work on Ricci flow and Black holes at Winona State, May 2021, at the Ramaley Research Collaboration.
- o 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).

### Scientific Literature.

- o My undergraduate thesis on Brans-Dicke cosmology with a fermionic field was written up and posted on my website which can be found on my website.
- o I have written a small summary paper on my research at Lehigh which can be found on their REU website: [physics.cas.lehigh.edu](http://physics.cas.lehigh.edu).
- o I have written of a summary of my work on Ricci flow and Black holes which can be found on my website: Ricci flow and Black Holes.

### Outreach.

- o I made and published a website dedicated to physics and my own work. My website is linked on the top right hand side of this CV. On my website, I also have made solutions for various textbooks, most of which are not yet completed, for instance: Cosmology by Peacock (ch. 1-12,18 finished), Strings in a Nutshell (chapter 2), and Loop Quantum Gravity by Rovelli (chapter 1-3).
- o I have written a small resource letter for undergraduates who want to study general relativity, but currently are at a university that does not have the means, or course structure to teach general relativity (less privileged schools). That article is also on my website.

## Skills

Languages  $\LaTeX$ , *Mathematica*, Python.

Utilities Anaconda, Git, and Jupyter Notebook

Communication English and French (4 years in high school and occasional practice).

## References

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