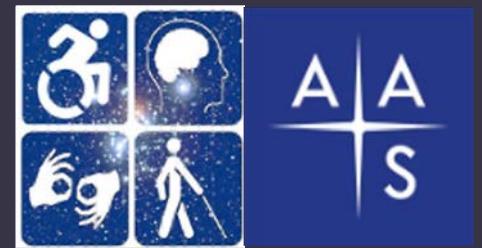


The UNCG-Stars

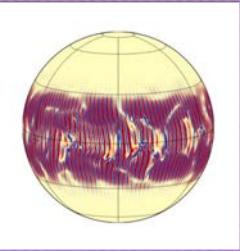
Undergraduate Research in Star Formation

Alicia Aarnio

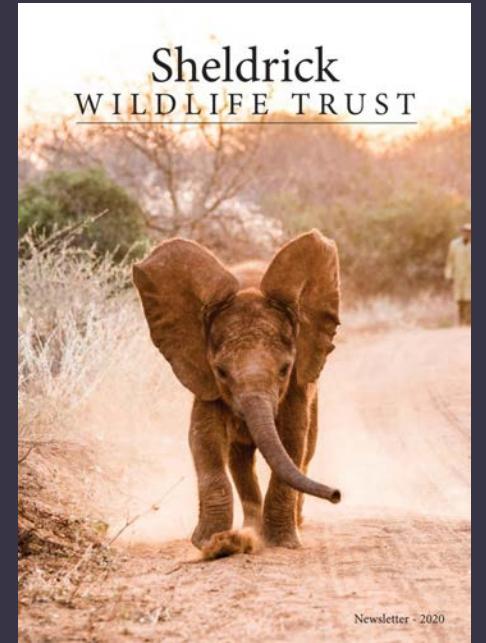
Assistant Professor of Physics & Astronomy



Talk road map



- A non-chronological trip through projects from the Sun, to stars, to galaxies, returning home at the end
- The elephant is in the room and will remain here for the duration of our talks; I will directly address it at various points
- An anonymously-built site, www.savetheg.com, is documenting the APR process and press coverage



Happier times



5 years later... APR timeline, part 1

- October 6, 2023: External analyst and accounting professor Howard Bunsis, hired by AAUP, presents results of his analysis: UNCG's finances are fine, there is no budget crisis. There's even some room for future hits if the administration plans well.
- 10/9: first draft of rpk GROUP rubric shared with faculty. Faculty scramble to verify data, correct numerous errors
- 10/23: final rubric spreadsheet as assembled by rpk GROUP released
 - Chancellor Gilliam still insistent there is no "list" of programs to be cut, even though spreadsheet now features sorting arrows
- Faculty given until 10/31 to draft 1000-word "contextual statements" if in rubric categories of "approaching expectations" or "needs examination"
- 3 forums scheduled to take questions from students, alumni, full campus
- 11/1: Faculty senate asks for faculty observers to be part of review process
- 11/20: Undergraduate curriculum committee points out "no one has asked us about any of this."
- 11/21, the day before break, Chancellor says no to faculty observers
- 11/29: AAUP submits petition with over 3000 signatures requesting suspension/discontinuation of process
- CAS budget and planning committee given until December 1 to review, supply recommendations to the college
 - 12/5: CAS College Assembly requests more time for adequate review
 - 12/10: Faculty senators ask for 2 more weeks
 - 12/12: Chancellor and provost say no to petition to suspend/discontinue process



Aidan Lytle

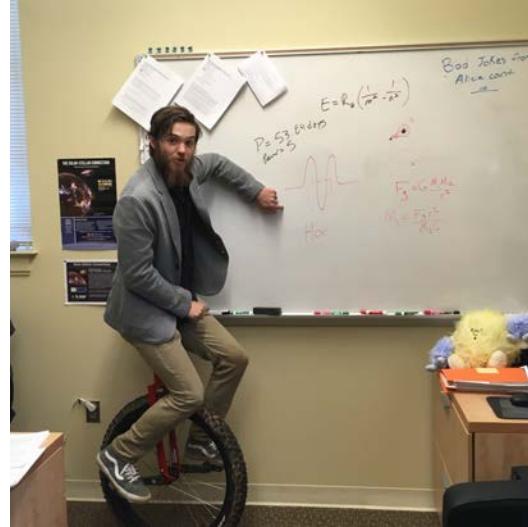
Topological Data Analysis Detects and Classifies Sunspots

With: T. Weighill, N. Pritchard

FALL 2019

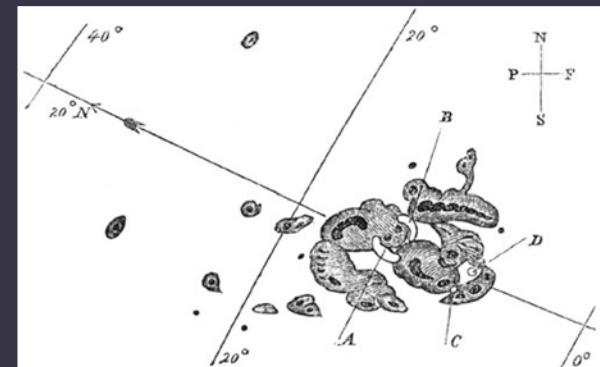
COLLISION COURSES

UNDERGRADUATE RESEARCH PROFILE



Motivation: automated space weather forecasting

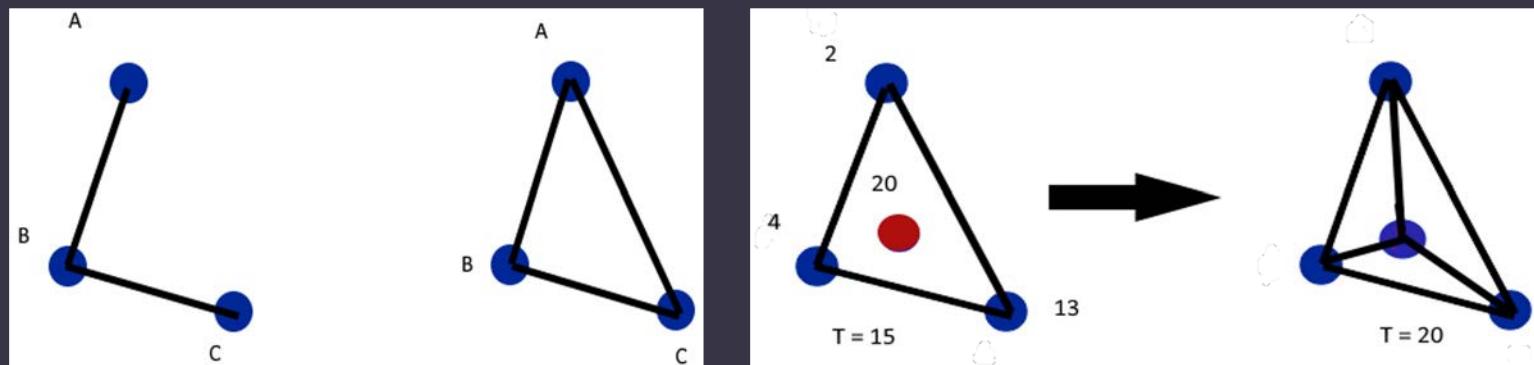
- Currently overdue for next Carrington Event-like storm
 - Last near miss was 2020
 - Infrastructure unprepared for events
- 2022: solar storm caused 40 Starlink satellites to drift into Earth's atmosphere
 - Caused \$100M in damage



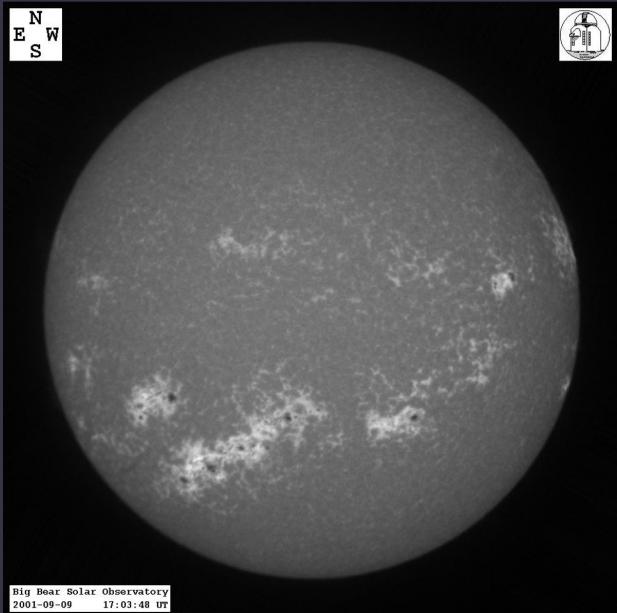
Sunspot group as drawn by
Richard Carrington on
September 1, 1859.

Topological Data Analysis

- Topological data analysis (TDA) aims to analyze the *shape* of highly dimensional data
- Can count “holes” in data using tools from algebraic topology
- Persistent homologies used:
 - 0th homology → connected components
 - 1st homology → number of holes



Proof of concept: can TDA detect sunspots?



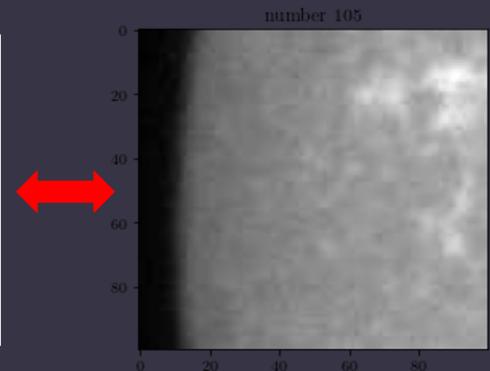
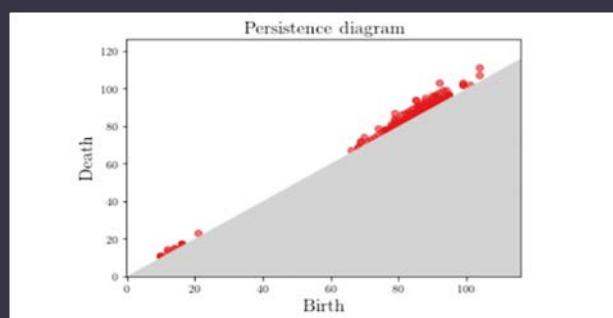
- Ca K images: very strong structurally representative data in grayscale
- **Prediction:** 1st homology detects sunspots at least as efficiently as current computational methods
- **Methods:** Construct 0th and 1st homology on cube complex of pixel data; use statistics from these
- **Goal:** Construct two simple binary classification systems: plage vs sunspots, using persistence statistics

Image data: Big Bear Observatory/Dutch Royal Observatory

Persistent Homology and Persistence Diagrams

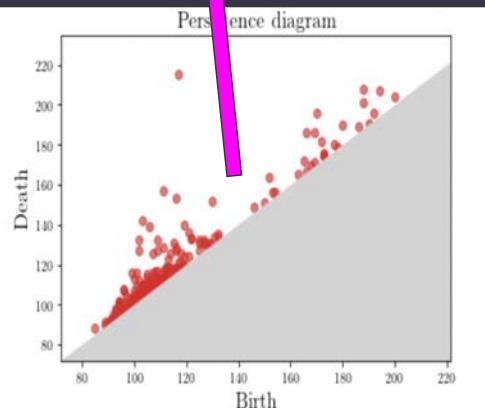
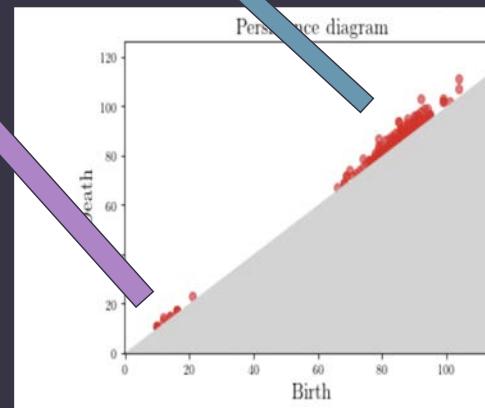
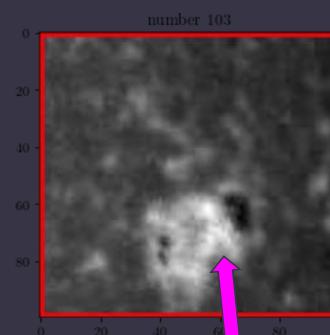
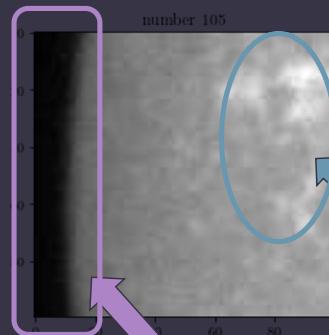
TDA produces a diagram of connected components

- This is called a persistence diagram
- Each (x, y) point tells us a feature of scale x disappears at scale y
- Persistence does best when detecting holes in noisy or large data that we may not be able to see



See: Chung, Hull, Lawson 2018 (Textures)

Does TDA Work? (Plage vs sunspot group)

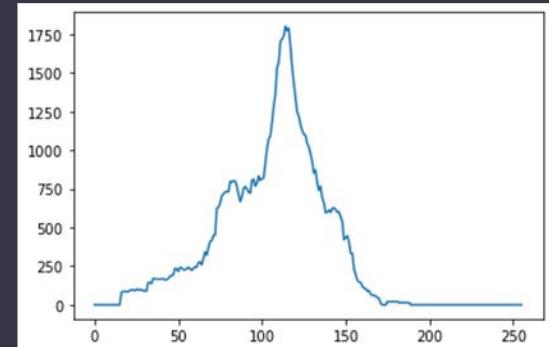
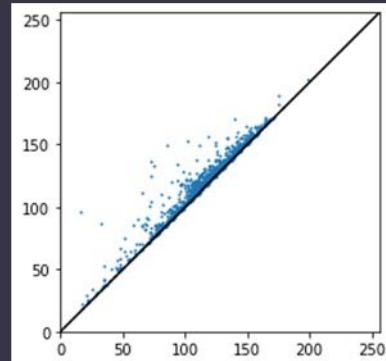
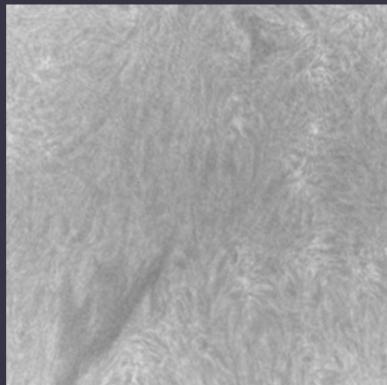


To the right: an inactive (left) and an active (right) region of the sun have noticeably different persistence diagrams for the 1st homology

- Yes

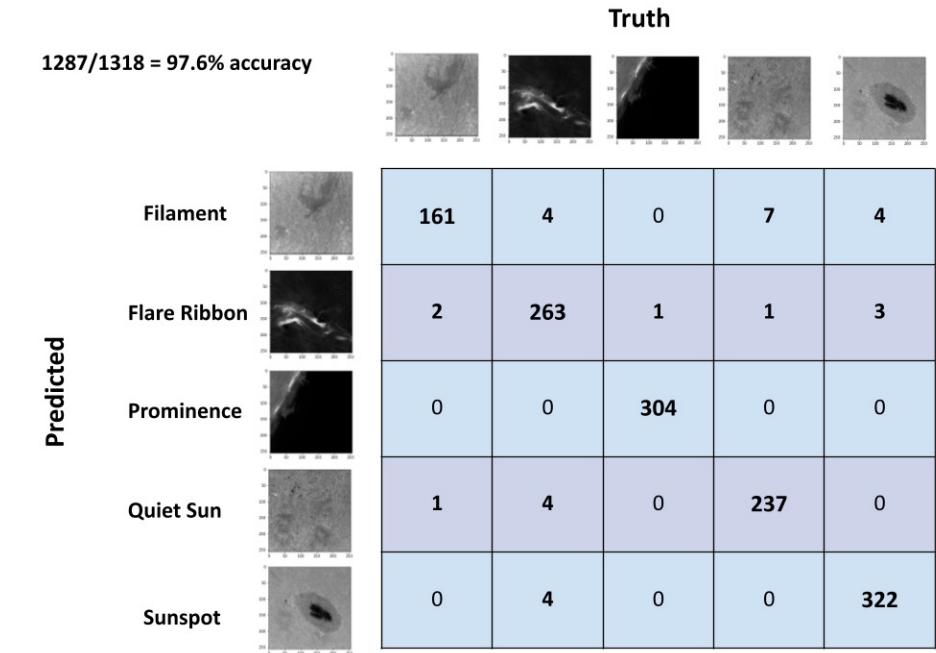
Our approach

- Persistence data are then binned; shape of this curve tells us about the solar feature that was observed
- The higher the peak, the sharper the contrast or more holes in that size range
- Once spot vs plage algorithm was working, complication added!



Does TDA Work?

- Yes
- 97% accuracy on a fully automated model with an 80/20 test/train split on ~1300 images



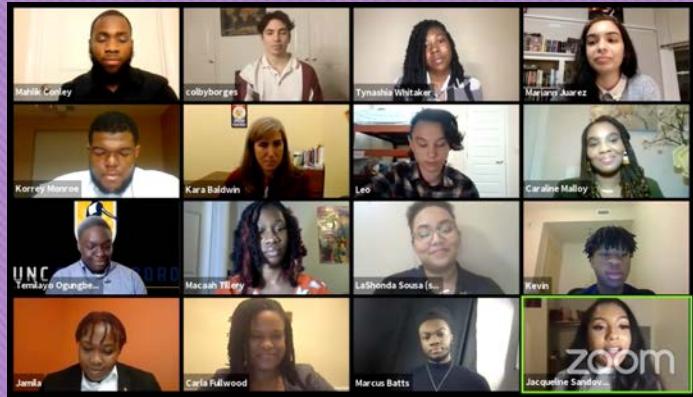
Current status

- Aidan went on to earn his Master's degree from the UNCG Math department.
- He is disappointed he will, apparently, not be able to return to complete his PhD as all of UNCG Math's graduate programs are slated for elimination.
- Aidan currently works for Boeing but stays in touch to help mentor UNCG physics students and give them advice.



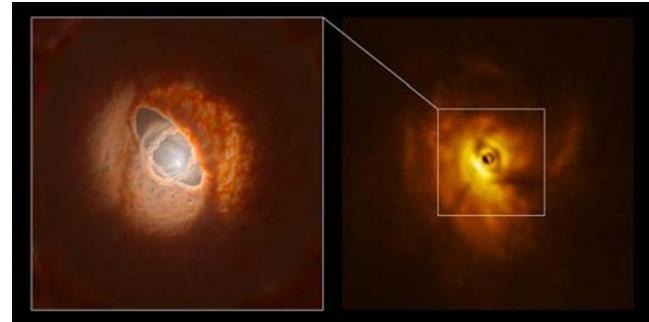
APR timeline, part 2

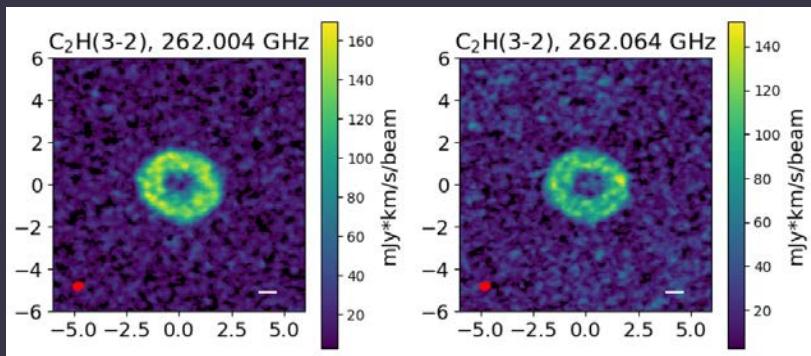
- January 16: Chancellor emails UNCG community with list of programs “proposed” for elimination
 - Says “the Deans made the recommendations”
- 1/17: Faculty senate passes a resolution that they do have authority over curriculum
- 1/20: General Education Council resolves that this is a really, really bad idea. Will hurt students
- 1/23: Undergraduate curriculum committee votes against program cuts, requests extension of process for review
- 1/24: Physics & Astronomy faculty meet with CAS Deans. They cannot tell us why we’re being cut, or...
 - What happens to the observatory? To the planetarium? To our tenure-track faculty?
 - “I don’t know.” The only question they did know the answer to was that any remaining faculty after “teach out” would be moved to Chemistry and shifted to teaching-only roles.
- 1/24: Rally Against Cuts organized by students held before, and within earshot of, Faculty Senate meeting
- 1/24: Faculty Senate approves resolutions to censure the Provost and Chancellor
- 1/24: Associate Dean Chuck Bolton resigns his position in protest. Cites “egregious” behavior of administration, pressure from Provost to add more programs to the cut list
- 1/30: Physics & Astronomy faculty meet with Chancellor and Provost. They did not know how much cutting us would save, how many faculty they’d need to deliver service courses. Focused on “DFW” rates, “misinformation;” praised our professionalism and civility
- 1/31: Faculty senate meeting opened the floor for impacted programs to make one final plea for our programs
 - Undergraduate curriculum committee points out via resolution, once again, that no one talked to them about any of this



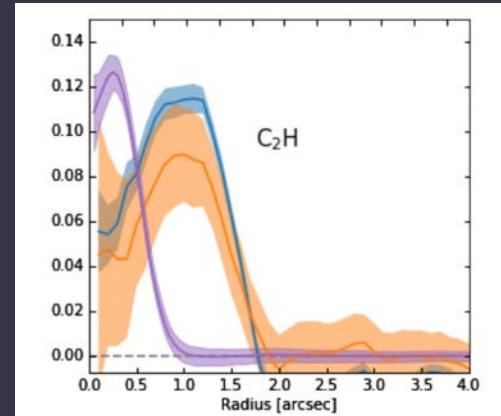
Mariann Juarez

The Protoplanetary Origins of the Building Blocks for Carbon-Based Life





Kastner et al. (2018)



Motivation

- Gas phase chemistry in circumstellar disks dependent on stellar parameters, disk structure
- Where are the inner edges/ice lines in disks around intermediate mass stars?
- How might this influence planet formation?

Radiative transfer modeling

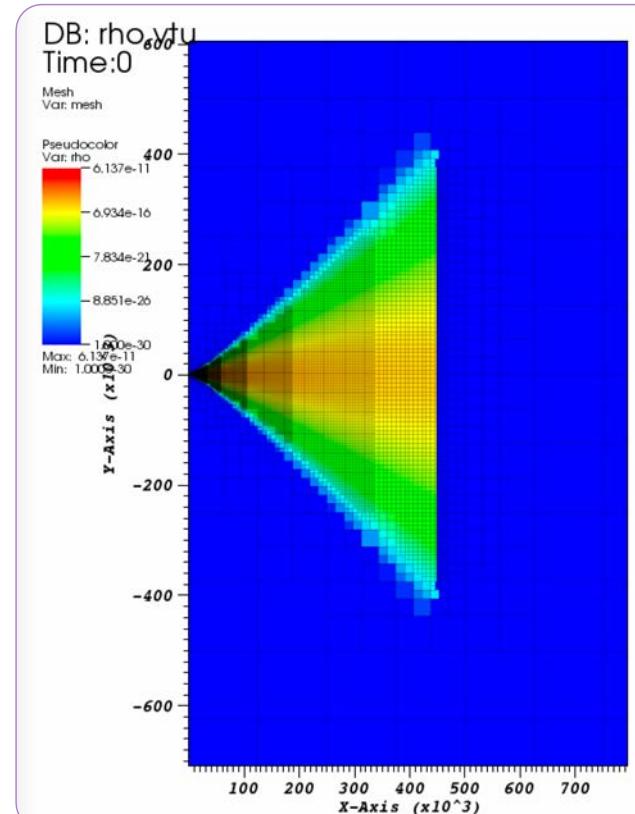
- Using TORUS (Transport Of Radiation Under Sobolev/Stokes), Mariann created a grid of disk models
- Computed emission of molecules:
 - CO
 - ^{13}CO
 - C₂H

Table 1. Stellar parameters for radiative transfer models

	Mass [M _☉]	Radius [R _☉]	Temperature [K]
Star 1	2.5	2.5	9250
Star 2	2.5	3.5	9000
Star 3	2.5	4.5	8750
Star 4	3.0	3.0	10450
Star 5	3.0	4.0	10300
Star 6	3.0	5.0	10150
Star 7	3.5	3.5	12000
Star 8	3.5	4.5	12150
Star 9	3.5	5.5	12300
Star 10	4.0	4.0	13250
Star 11	4.0	5.0	13000
Star 12	4.0	6.0	12750
Star 13	4.5	4.5	14750
Star 14	4.5	5.5	14500
Star 15	4.5	5.5	14500
Star 16	5.0	5.0	14250
Star 17	5.0	6.0	18250
Star 18	5.0	7.0	18000

Disk structure

- Calculated an inner edge for each star's disk based on the stellar temperature and radius
- TORUS starts with input, iteratively calculates thermal equilibrium to set inner disk edge



Model suite

The Protoplanetary Origins of the Building Blocks for Carbon-Based Life

MARIANN JUAREZ¹ AND ALICIA N. AARNIO 

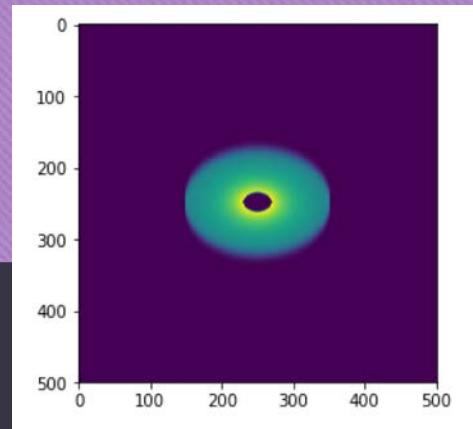
¹University of North Carolina Greensboro
P.O. Box 26170
Greensboro, NC 27402

ABSTRACT

It is known that stars are formed from a cloud of gas and dust. The planets that would be in this star's solar system would be formed from that same exact gas and dust that is produced in the star's protoplanetary disk. There have been previous studies on the chemistry of protoplanetary disks and how specific molecules and compounds affect it. We are using their findings to support what we may find. This is to better understand where planets come from and why carbon is so important for us. We use TORUS, an open source radiative transfer code, and a 40-core workstation to create computational models and simulations of 18 different stars with varying mass, radius and temperature. A lot of thought has been put into the sizes and temperatures of the stars, we are viewing how these parameters may affect the size and density of the protoplanetary disk. We are focusing on molecules that make an impact on the formation of carbon-based life, we are going to look at Carbon Monoxide, Hydroxide and Ethynyl, CO, OH and C₂H. As well as ¹³CO and CO with a transition of 2-1 which are variants of Carbon Monoxide. We compare the abundances of these molecules and how they may affect the chemistry of the protoplanetary disk. We found that overall the chemistry of CO is more excitable than OH, but OH has interesting characteristics that allow it to create a shadow of emission emitting from the disk.

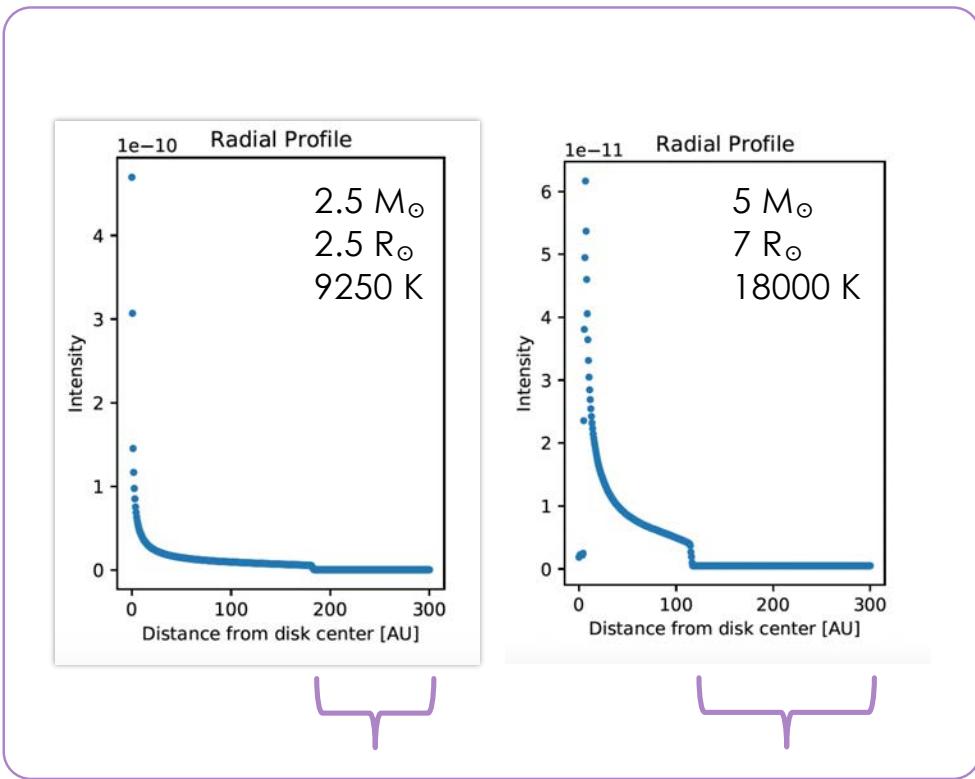
Keywords: Protoplanetary disks (1300) — Circumstellar disks (235) — Planet formation (1241) — Planetary system formation (1257) — Astrochemistry (75) — Interdisciplinary astronomy (804) — Computational astronomy (293) — Computational methods (1965) — Radiative transfer (1335)

- Shown here: 2.5 M_⊙ star, 9250 K
- Animation scanning through velocity cube for a Herbig Ae-like star
- CO emission; continuum + N=2->1 transition



Results

- Models well reproduce ring-like structure observed
- Inner disk edge moves outward as stellar mass increases
- Unexpected: outer edge of gas moved inward as well!
 - Disk flaring/self-shielding?
- Big picture takeaway:
intermediate-mass stars don't
always behave like low-mass
stars but scaled-up!



Frozen out

Frozen out

Where is Mariann now?

- Mariann worked in the Sardashti lab at Clemson University, Summer 2023.
- She plans to reapply for graduate schools after building a solid background in laboratory physics.



Researcher Mariann Juarez studies the stars.

ARGAZING SCIENTIST

The Imminent Supernova of Betelgeuse

Human cost, loss of access

- At the faculty senate meeting, I shared these data.
- This is why programs like ours are important: two of our recent graduates alone will increase the number of Black men physics PhDs in the year they graduate by up to 25%
- Faculty senate voted on/approved resolution opposing the proposed cuts

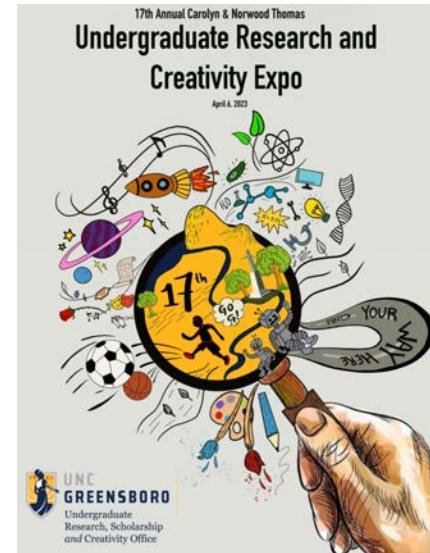
The Number of Doctorates Earned in Physics, 2014–15 to 2018–19

Number of Doctorates Earned in Physics by People who are:	2014–15	2015–16	2016–17	2017–18	2018–19
American Indian or Alaska Native men	5	0	1	2	2
American Indian or Alaska Native women	0	1	0	0	0
Asian men	56	55	61	66	70
Asian women	17	20	19	18	27
Black or African American men	13	15	16	8	8
Black or African American women	5	9	3	4	1
Hispanic or Latino men	34	40	50	42	40
Hispanic or Latino women	10	5	7	11	10
Native Hawaiian or Other Pacific Islander men	2	1	1	1	1
Native Hawaiian or Other Pacific Islander women	0	0	0	1	0
White men	639	650	648	609	651
White women	135	142	115	165	123
Two or more races men	9	11	11	24	22
Two or more races women	1	8	6	6	6
All Other Race/Ethnicity and Gender Combinations (NonResident Alien and Unknown)	915	889	894	923	914
Totals:					
Non-White Only	152	165	175	183	187
White Only	774	792	763	774	774
Grand Totals:					
Men	1,474	1,489	1,511	1,478	1,497
Women	367	357	321	402	378
All	1,841	1,846	1,832	1,880	1,875



Madison Gullett

Understanding Magnetic
Field Generation In
Intermediate-Mass Young
Stars



(STEM) Mathematics, Life and Physical Sciences

1st Place: Sarah Korb (Biochemistry, Senior), Mentor: Kimberly Petersen (Chemistry), *Enantioselective Tandem Deprotection-Cyclization of Alcohols to Form Lactones*

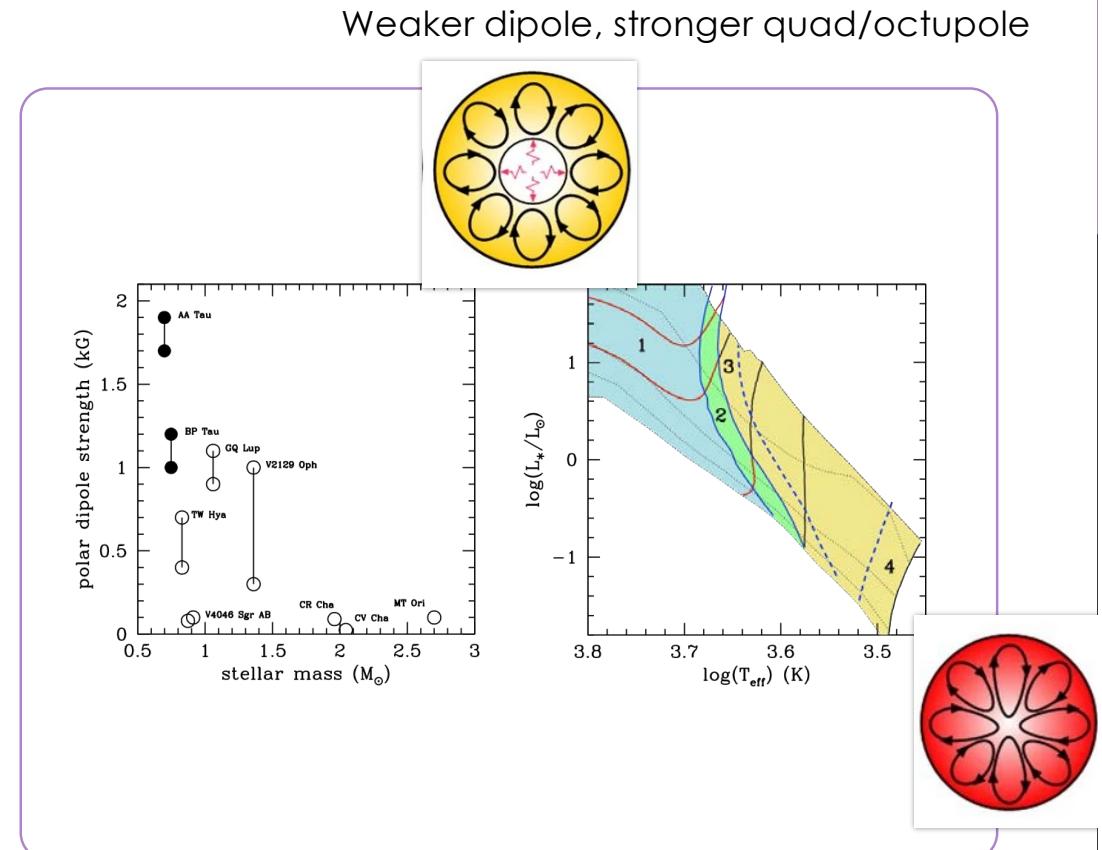
2nd Place: Daniel Araya (Biology), Mentor: Ayalew Osena (Biology), *Expression of Pyrococcus furiosus thioredoxin (PfTrx) in transgenic tobacco for enhanced abiotic stress tolerance*

3rd Place (tie): Kate Tirrell (Biology, Post-Bac) and Kristen Mitchell (Biology, Post-Bac) Mentor: Amy Adamson (Biology), *Epstein-Barr Virus Replication Triggers Cancer Cells to Migrate; Madison Gullett (Physics & Astronomy, Senior), Mentor: Alicia Aarnio (Physics & Astronomy), Understanding Magnetic Field Generation in Intermediate-Mass Young Stars*



Stellar interiors and magnetic fields

- Motivation: “the magnetic H-R diagram”
- It’s difficult to get time to observe when it may lead to non-detection!
 - So, we’re modeling instead!



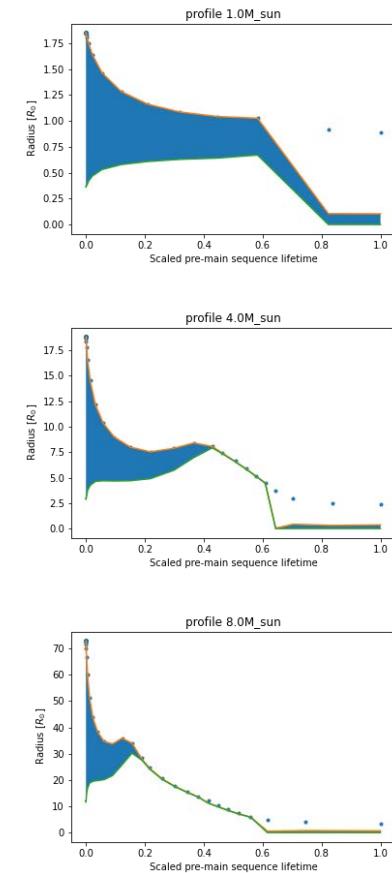
Strong dipole moment

MESA

- Modules for Experiments in Stellar Astrophysics (MESA) is a 1-dimensional code simulating stellar interiors
- Includes the pre-main sequence, while stars are still in the process of contracting

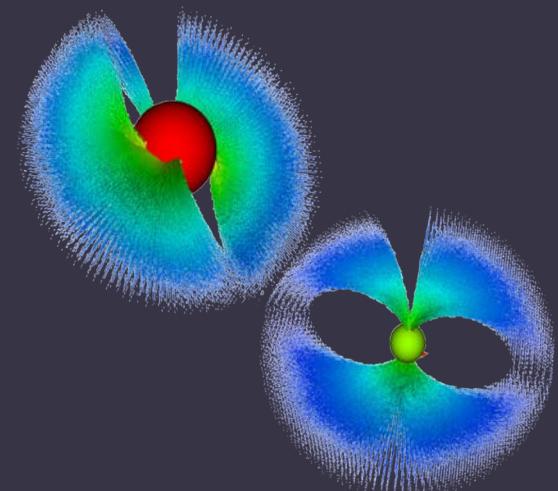
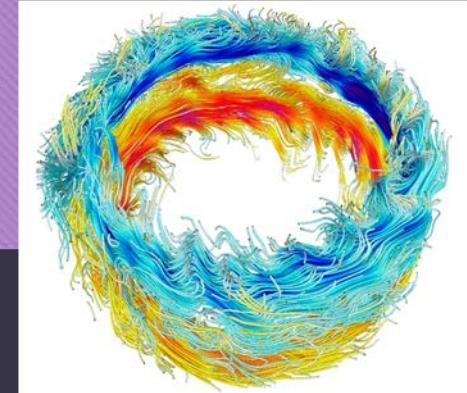
Results

- Going to higher mass stars, we still find periods during which large fractions of their interiors are convective!
 - Could this be the origin of a “fossil field” the star can sustain throughout its life?



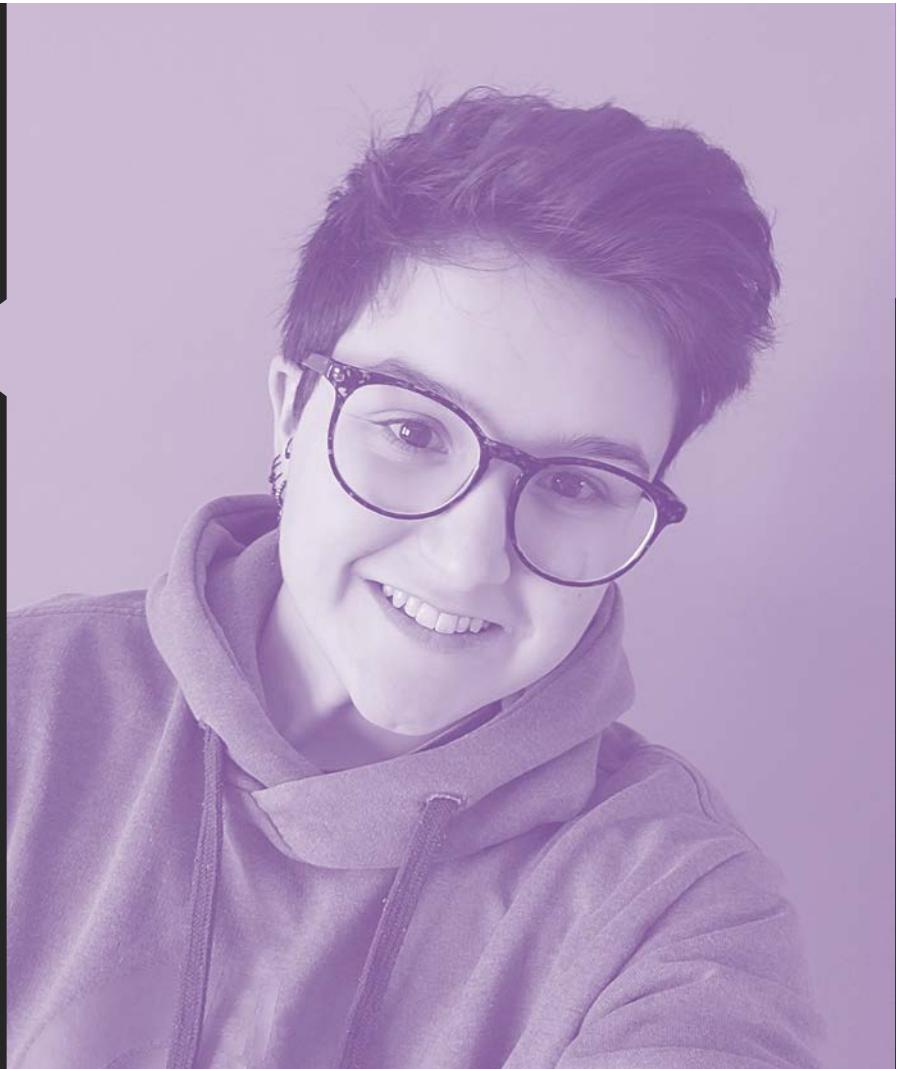
To-do

- MESA model setups can be input to Dedalus, 3-dimensional interior convection model
- Simulates magnetic field generation: can use as lower boundary condition for external magnetic field extrapolation
 - Would demonstrate for the first time what the magnetic field of an intermediate-mass star looks like



What is Madison up to?

- Madison will be graduating from UNCG this spring!
- After some time off, Madison plans to seek a graduate degree.
- *"I find the thought of a Physics and Russian program at a University being discontinued distasteful. ... I have learned so much from not only my classes but my professors throughout the four years I have attended UNCG, and it is extremely disheartening to me to think my professors that have got me to where I am at will no longer be here or the courses that shaped who I am will no longer exist. You can't simply replace these professors, they're like no other."*



APR timeline, part 3

- 2/1: Current faculty and students, as well as incoming accepted/committed students all emailed within moments of each other with final list of cuts, notices of what they will not be allowed to major in beginning Fall 2024
- Departments up for elimination notified, in some cases, 10 minutes before emails went out to entire campus community. Some faculty learned from students while teaching their classes.
- Community told in message that “teach out” will take “years;” there will be “no immediate changes to staffing or programming” and students currently in programs will be able to finish
 - (5 days elapse)
- 2/6: Faculty in impacted programs (3 Physics & Astronomy, 2 Math & Stats, 1 Languages, Literature & Cultures) sent “Faculty Realignment Incentive Program” letters. Buy-out offers. Faculty given until 2/29 to decide
- 2/14: Our chair is told we will no longer be allowed to offer astronomy classes
- 2/23: Lecturers in Anthropology and Physics & Astronomy fired via contract non-renewal
- 2/27: When told that even cutting astronomy that losing our lecturer will make us unable to cover classes, we’re told to cut lab sections and double the remaining sections
- 2/28: CAS has assembly meeting, members of impacted departments speak. Faculty overwhelmingly vote no confidence in Dean Kiss, Provost Storrs



Kamara Culbreath

The composition and orbit of stars and gases in a tidally disrupted starburst galaxy

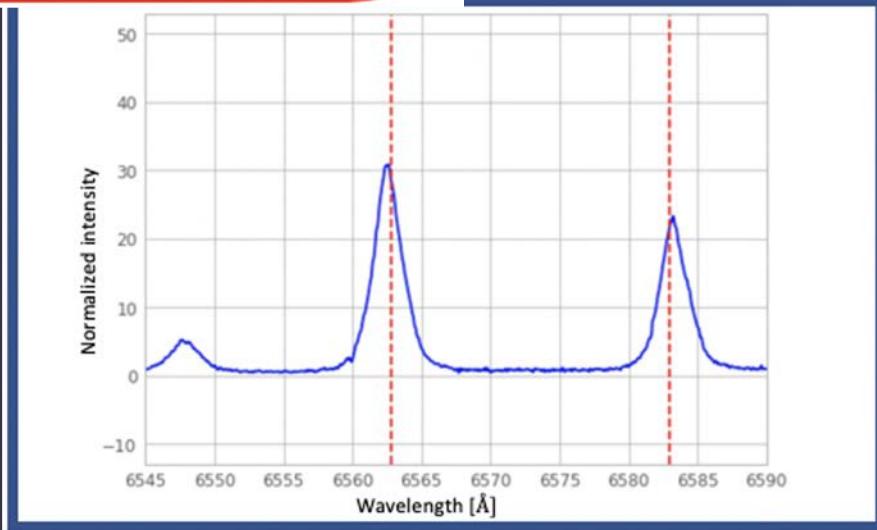
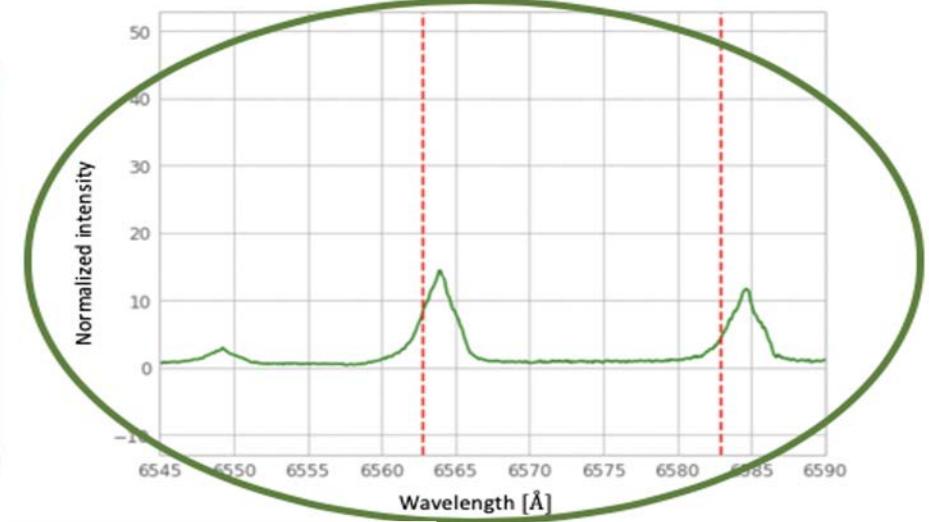
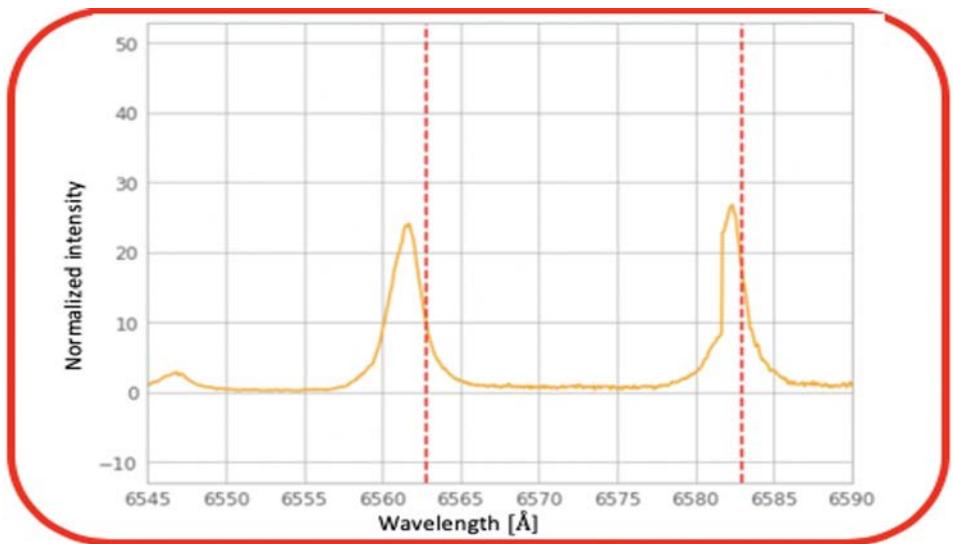




The Astronomical
Research
Consortium (ARC)
3.5 m telescope
Echelle
Spectrograph
(ARCES)

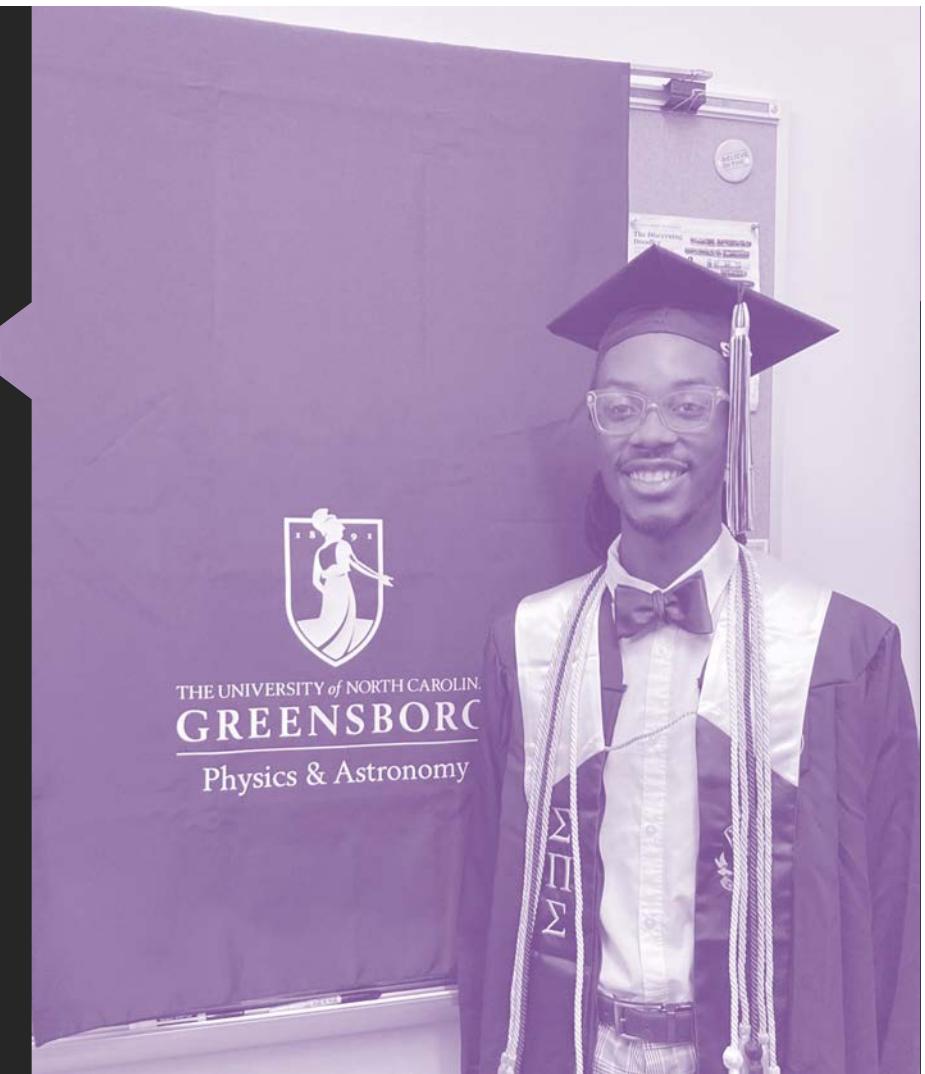
Spectroscopic observations of M82





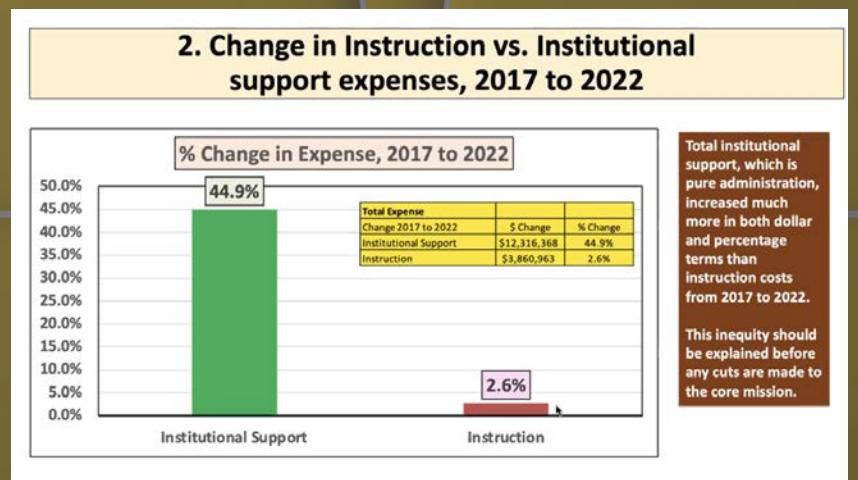
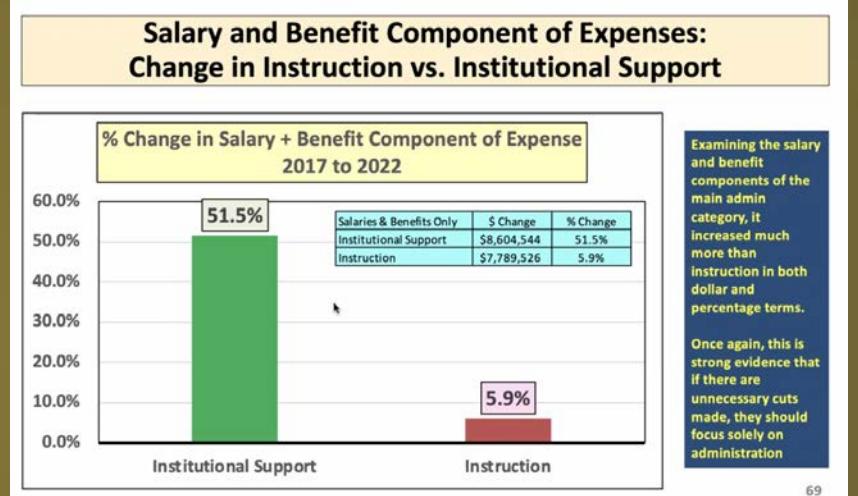
Where is Kamara now?

- Kamara is a graduate student in the Fisk-Vanderbilt Bridge program. He will be defending his Physics MS dissertation this spring.
- In the Fall, he will enroll in the Astrophysics PhD program at Vanderbilt.
- He told me, “I really hate that things are not going well at UNCG right now.”

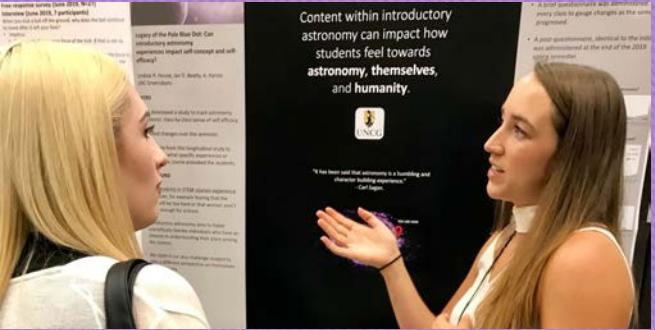


A tale of two budgets

- Bunsis report highlighted poorly managed investments, dramatic increase in administrative costs, low salaries relative to peer institutions, athletics in the red by at least \$10M every year
- At no point has a state of financial exigence been declared
- At no point have the Deans, Chancellor, Provost, or any administration provided budgetary numbers on savings that will come from eliminating programs
- **We still have not been told why we're up for elimination.**



College	Department	Percent C	Duplicate	Average S	Average M	Average SCH/AFTE	Average A	Avg. Degr	Avg New I	Avg New I	Avg Trans I	Avg Trans I
College of Total		-12%	-2052	241,640	23	484.4	497	1,605	77.6%	54.5%	71.3%	59.9%
	Philosophy	9%	22	11,107	40	750.7	15	18	79.2%	54.7%	62.5%	54.5%
	Classical Studies	15%	13	5,896	23	666.5	9	7	80.6%	69.4%	100.0%	83.3%
	Psychology	-2%	-47	19,401	40	629.3	31	238	78.1%	56.6%	75.6%	60.2%
	Mathematics and Statistics	-12%	-35	20,460	35	604.8	34	28	60.6%	38.9%	72.5%	45.0%
	Chemistry & Biochemistry	-19%	-158	14,202	22	591.1	24	51	69.2%	38.7%	48.6%	38.5%
	Biology	-6%	-146	25,028	22	556.5	46	180	77.8%	48.0%	65.6%	52.4%
	African Amer/African Studies	-50%	-65	3,699	37	546.4	6	10	75.0%	62.5%	100.0%	100.0%
	Liberal/Prof Studies	-27%	-498	10,296	23	537.6	17	234	86.3%	69.8%	72.8%	68.2%
	Physics and Astronomy	-34%	-42	4,478	26	534.5	8	6	71.2%	42.8%	61.6%	39.3%
	Sociology	-28%	-312	12,253	34	527.4	23	119	80.2%	63.5%	74.7%	68.1%
	Anthropology	-53%	-144	5,647	26	503.2	11	19	84.6%	59.0%	76.8%	63.4%
	Religious Studies	-24%	-17	5,142	30	491.6	11	6	100.0%	100.0%	75.0%	75.0%
	Communication Studies	-29%	-289	13,369	25	479.9	28	110	74.4%	56.6%	84.8%	75.6%
	Special Programs			1,836	14	430.3	2					
	History	-27%	-197	11,613	33	429.6	27	79	75.6%	57.4%	82.2%	67.9%
	Computer Science	29%	327	6,531	27	425.3	15	86	77.3%	54.9%	74.0%	57.8%
	Geography/Environment	85%	178	8,143	20	424.8	19	36	79.2%	58.3%	70.2%	58.4%
	Media Studies	-17%	-137	6,329	20	423.0	15	74	77.5%	65.9%	80.6%	67.7%
	Women's, Gender, and Sexuality Studies	-19%	-30	2,497	37	414.3	6	15	72.2%	33.3%	83.3%	83.3%
	Languages, Lit and Culture	-31%	-142	21,129	20	393.2	54	30	88.5%	61.0%	86.2%	72.6%
	Political Science	-16%	-153	6,763	22	385.8	18	105	84.8%	68.9%	72.8%	66.6%
	English	-18%	-162	20,996	22	349.8	62	90	77.4%	59.1%	75.9%	64.4%
	Interior Architecture	-13%	-67	4,194	16	331.9	13	50	84.8%	67.4%	86.0%	78.6%
	Informatics and Analytics	117%	54	636	7	109.6	4	16				
	Global Studies	-45%	-5					3				



Lindsay House

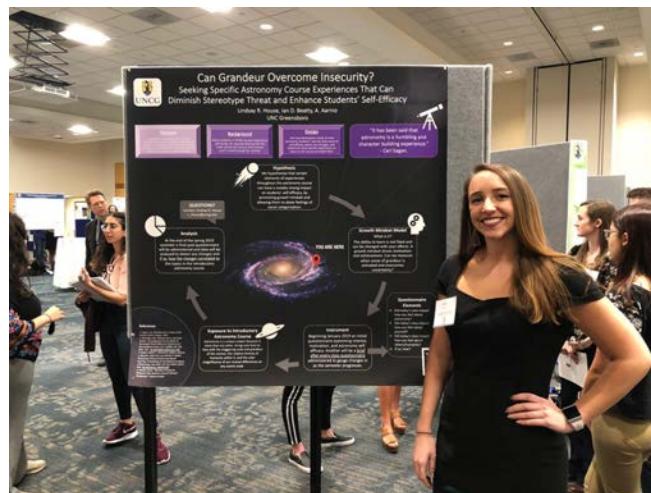
Legacy of the pale blue dot: Can introductory astronomy experiences impact mindset and self-efficacy?

Content within introductory astronomy can impact how students feel towards astronomy, themselves, and humanity.



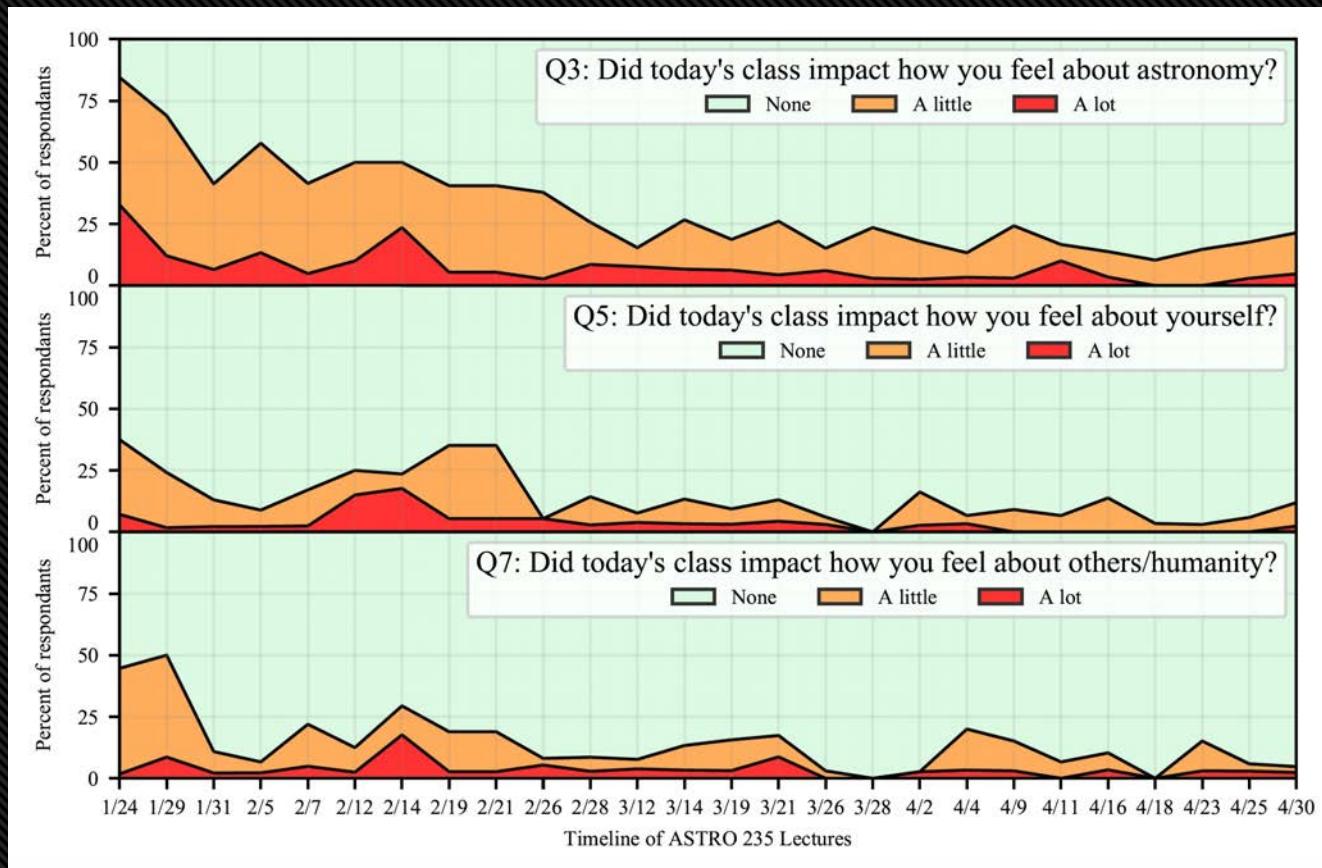
"It has been said that astronomy is a humbling and character building experience."

- Carl Sagan



Astronomy education research

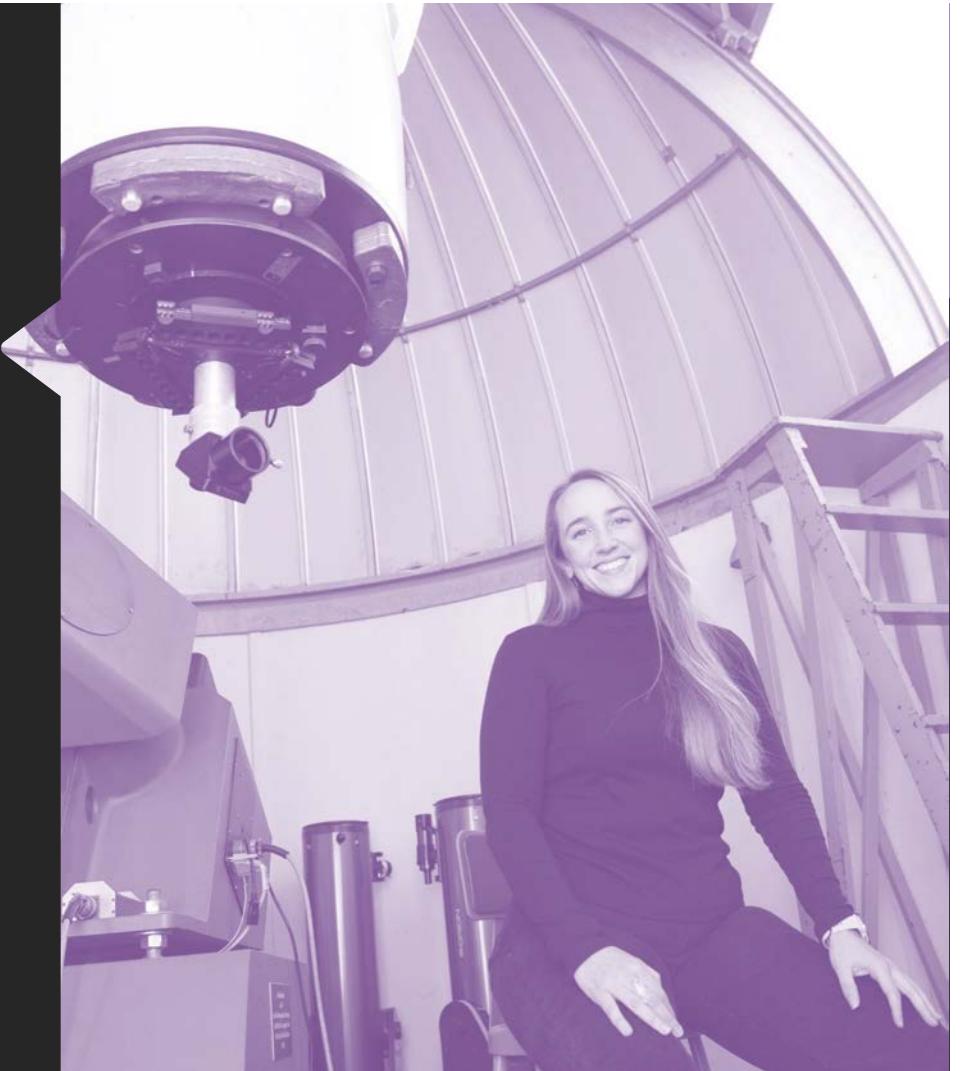
- Can impactful experiences in introductory astronomy courses shape the way students view astronomy, themselves, or the world around them?
- Can experiences help support a growth mindset in students? Enhance their self-efficacy? Make students feel more academically in control?



Date	Class Topic/Activities	Q3 Responses		Q5 Responses		Q7 Responses	
		A little	A lot	A little	A lot	A little	A lot
1/24	Planetarium visit/Moon phases and eclipses discussion	52%	33%	30%	7%	43%	2%
1/29	Observing our night sky/Moon phases	57%	12%	22%	2%	41%	9%
1/31	Scientific method, kinematics/discussion of physics ideas that go into potentially re-directing Earth-bound impactors such as asteroids	35%	7%	11%	2%	-	-
2/5	Conservation laws in physics/momenta conservation demonstration (billiard ball impacts, curling)	44%	13%	-	-	-	-
2/7	What is light?/Video demonstrating visualizing WiFi signals (“Light painting”)	37%	5%	15%	2%	17%	5%
2/12	Light and matter/Pre-class discussion of article, focusing on stereotype threat, growth mindset	40%	10%	10%	15%	-	-
2/14	Telescopes and exploration/“Pale Blue Dot” video	26%	24%	6%	18%	12%	18%
2/19	Review session for first midterm exam	35%	5%	30%	5%	16%	3%
2/21	Midterm exam 1	35%	5%	30%	5%	16%	3%
2/26	The Sun/Magnetic field demonstration with twisted yarn bundle, many movies of solar wind, flares, and coronal mass ejections; discussion of space weather and impacts of geomagnetic storms	35%	3%	-	-	-	-
3/21	End of stars’ lives/Discussion: what happens when Sun-like stars exhaust their Hydrogen supply?	-	-	-	-	9%	9%
4/2	Midterm 2 exam	-	-	14%	3%	-	-
4/4	Life on Earth/Video, “How Life Came to be on Earth”	-	-	-	-	17%	3%

What's Lindsay up to?

- Lindsay is an astrophysics PhD candidate at UT Austin and NSF Graduate Research Fellow
- Her work interleaves astronomy education research, citizen science, and machine learning to understand dark energy
- She is the creator of Dark Energy Explorers, a citizen science project



Conclusions

- How do we think about the measure of our impact, of our careers?
- Thank you for your attention, and your support of us and astronomy in NC. This isn't over! We will continue pushing back to #savetheg



Louise Miller 🐐
@louisethebaker

I'm almost 50, and here is the best thing I have learned so far: every strange thing you've ever been into, every failed hobby or forgotten instrument, everything you have ever learned will come back to you, will serve you when you need it. No love, however brief, is wasted.

