Pathways in Physics

Top Careers in Physics and Astronomy

OCCUPATION	JOB SUMMARY	ENTRY-LEVEL EDUCATION	MEDIAN PAY 2021
Physics research & development	Explore the fundamental laws that govern space, time, energy, and matter.	Ph.D.	$152,430
Astronomy research & development	Study planets, stars, and other celestial bodies.	Ph.D.	$128,160
Federal government	Varies widely	MS or BS	$125,220
High school teacher	Teach science	MS or BS	$61,820
Healthcare services	Example: Medical physics	BS or MS and certification	$208,000+

https://www.bls.gov/ooh/life-physical-and-social-science/physicists-and-astronomers.htm#tab-2

Employment outlook

Occupation	Employment - 2021	Projected Employment - 2031	Change, 2021-31	
			Percent	Numeric
Astronomers and physicists	25,200	27,200	+8%	2,000
Astronomers	2,200	2,400	+6%	100
Physicists	23,000	24,800	+8%	1,900

Largest employers in Astronomy

OCCUPATION	% OF TOTAL
Research and development in the physical, engineering, and life sciences	41%
Colleges, universities, and professional schools; state, local, and private	24
Federal government, excluding postal service	22

Largest employers in Physics

OCCUPATION	% OF TOTAL
Scientific research and development services	44%
Federal government, excluding postal service	15
Colleges, universities, and professional schools; state, local, and private	12
Ambulatory healthcare services	2

Example jobs for physicists

- ***Atomic, molecular, and optical physicists*** study atoms, simple molecules, electrons, and light.
- ***Computational physicists*** study the use of algorithms, numerical analysis, and datasets to explore the interaction between theoretical and experimental physics.
- ***Condensed matter and materials physicists*** study the physical properties of matter in molecules, nanostructures, or novel compounds.
- ***Health physicists*** study the effects of radiation on people, communities, and the environment.
- ***Medical physicists*** work in healthcare and use their knowledge of physics to develop new medical technologies.

Example jobs for physicists

- ***Particle and nuclear physicists*** study the properties of atomic and subatomic particles, such as quarks, electrons, and nuclei and the forces that cause their interactions.
- ***Plasma physicists*** study plasmas, a distinct state of matter that occur naturally in stars and interplanetary space and artificially in products such as neon signs and fluorescent lights.
- ***Quantum information physicists*** study ways to use quantum objects, such as atoms and photons, to probe information processing, computing, and cryptography.

Example jobs for astronomers

- ***Cosmologists and extragalactic/galactic, planetary, and stellar astronomers*** study the creation, evolution, and possible futures of the universe and its galaxies, stars, planets, and solar systems.
- ***Optical and radio astronomers*** use optical, radio, and gravitational-wave telescopes to study the motions and evolution of stars, galaxies, and the larger scale structure of the universe.

Earning degrees in the field

- BS in physics
  - Typically, 4 years of study
- MS in physics
  - Typically, 2 years of study past the BS
- PhD in physics
  - Typically, 3 years of study past the MS

UTD offer Financial aid and other help

Many times – one can be paid to earn these degrees

Undergraduates in Physics at UTD

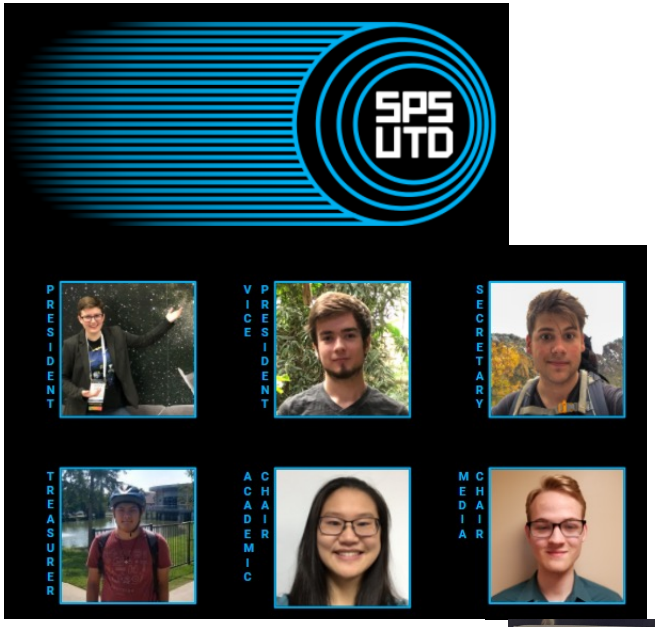
- UT Dallas Physics department
  - Graduates ~30 BS students/year
    - #75th in size out of 680 total programs
      - Big enough to give students options
      - Small enough to give students personal attention

- Many of our UG students
  - Get involved in Society of Physics Students
  - Get involved in research

SCHOOL OF NATURAL SCIENCES AND MATHEMATICS
The University of Texas at Dallas

UT DALLAS

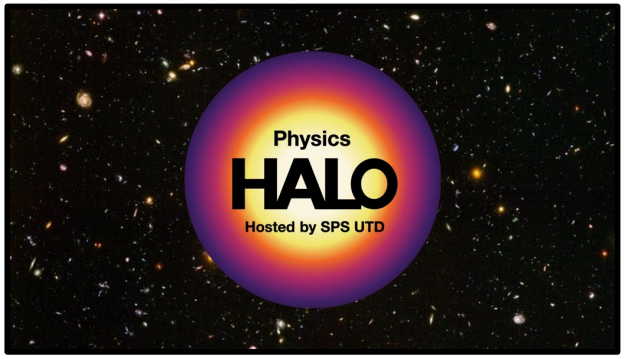
UTD chapter of Society of Physics Students



Victoria Catlett	Co-President
Brandon Sike	Co-President
Benjamin Walker	Secretary
Alexander Obenza	Treasurer
Leigh Preimesberger	Academic Chair
Ian Schreiber	Media Chair
Dr. Jason Slinker	Faculty Advisor

National Service Award

US Student Representative to the SPS Executive Committee

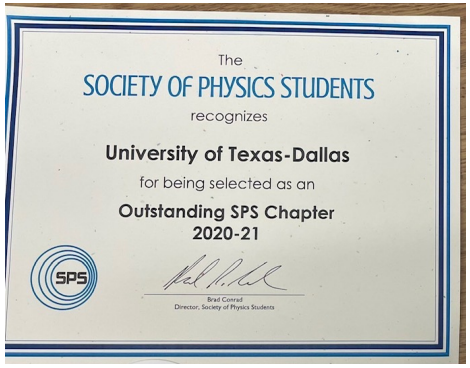


2X Future Faces of Physics Award
Blake Lily Award Winner

SPS Outstanding Chapter Award
<10% receive this
4th Consecutive Outstanding Award
9th Consecutive Chapter Distinction

Physics HALO: Giving high school women scientific computing skills to be successful as a physicist.

The Blake Lilly Prize:
influence general public about physics.



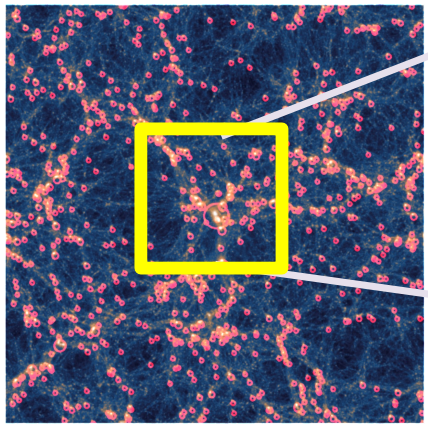
Undergraduate student involvement in Astrophysics research

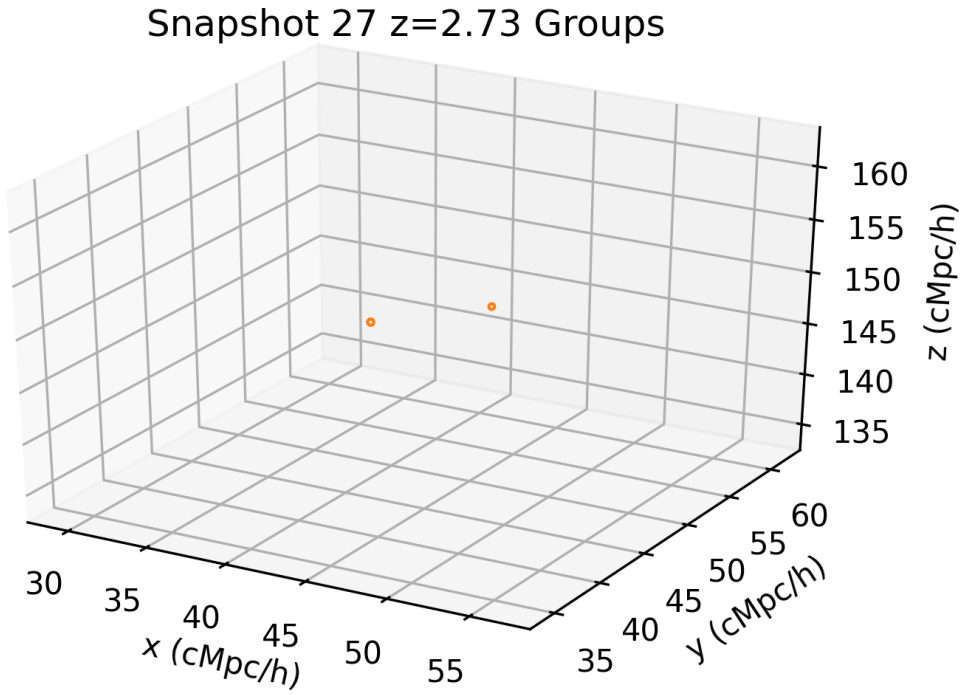
How do galaxies and clusters of galaxies grow in the Universe?

In a few billion years, our Milky Way will collide with Andromeda galaxy, forming a GIGANTIC galaxy!…

Galaxies moving under gravity during *past* 10 billion years!

Cluster of galaxies on sky at present day (z=0)

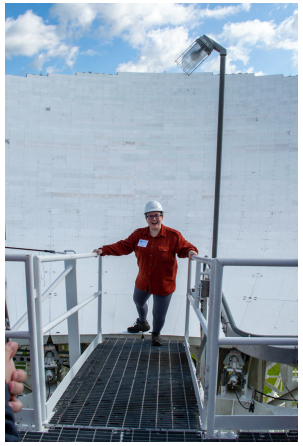




Brandon Sike (UTD), using huge computer simulations Illustris-TNG

Career Paths? Trayectoria Profesional?

Examples of Dr. Lindsay King's former astrophysics research students
Ejemplos de antiguos estudiantes que hicieron investigación en astrofísica con la Dra. Lindsay King



Victoria Catlett
Telescope computer software engineer
Greenbank Observatory, W. Virginia
(High School Allen)

Samantha Enriquez
5G Project Coordinator, Plano
(High School Dallas)

Evan Meade
Analyst (computer modeling)
Goldman Sachs, Dallas
(High School San Antonio)

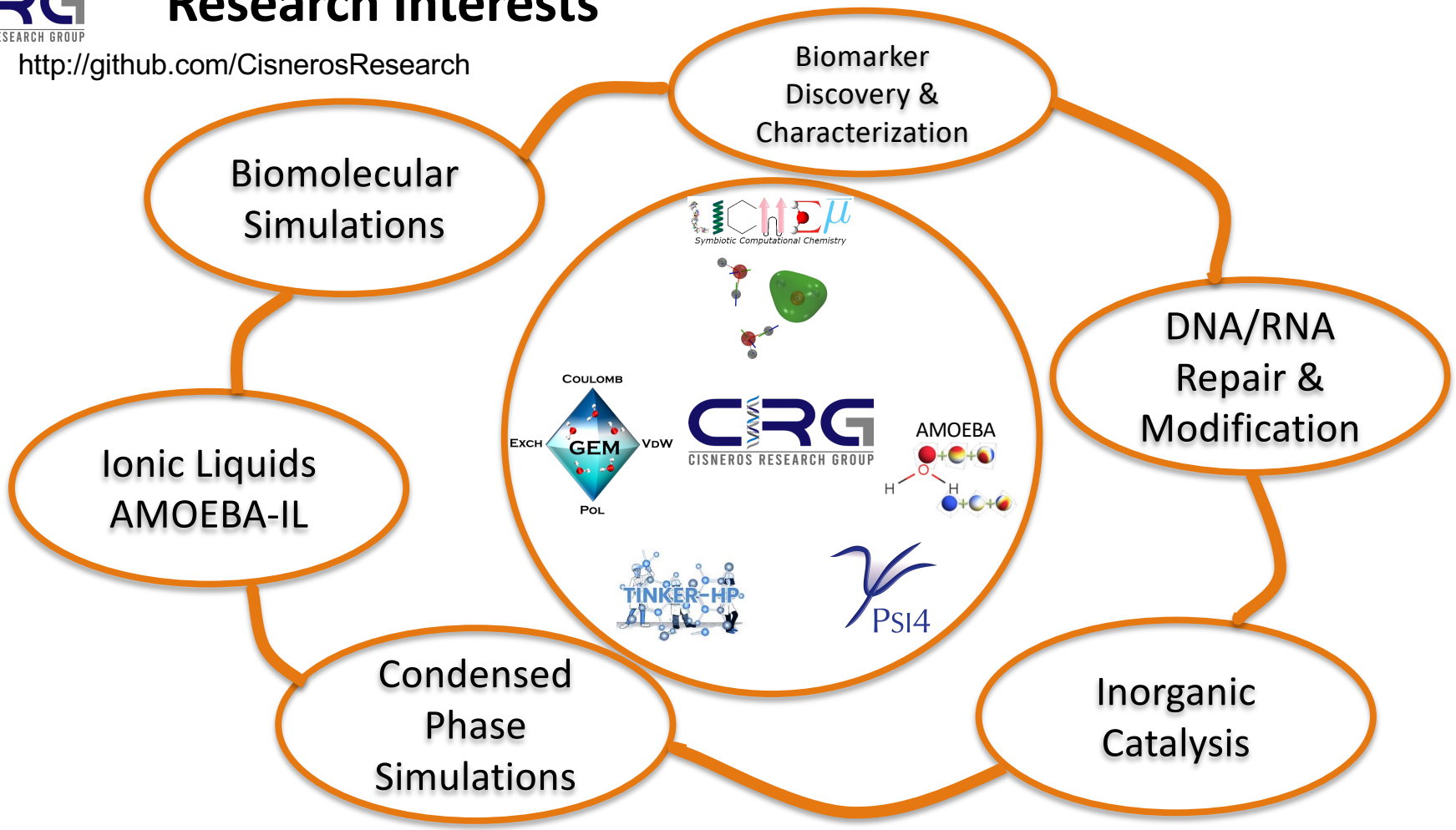
Danny Eilbott
PhD Student @UC Berkeley, California
(High School Austin)

Undergraduate student involvement in

Biophysics research

Research Interests

http://github.com/CisnerosResearch



CRG
CISNEROS RESEARCH GROUP

UG current/recent previous research

-Implementation of algorithms for protein NMR spectra calculations with polarizable potentials (A. Kumar)

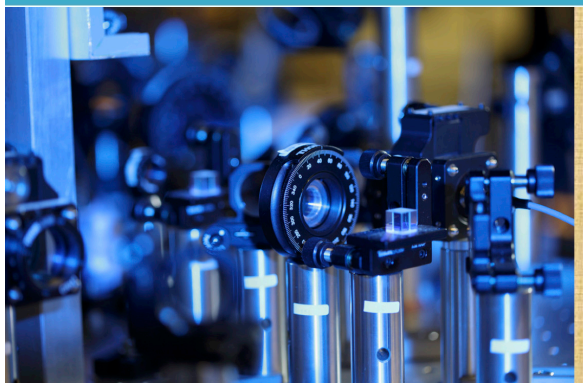
-Prediction of compensatory mutations in proteins
(K. Ravishankar, https://doi.org/10.1016/j.bpj.2022.05.036)

-Biomolecular simulations for protein investigation and cancer mutation characterization
(B. Boysan https://doi.org/10.1016/j.jmb.2021.167306;
M. Fang https://doi.org/10.1016/j.dnarep.2018.07.010)

Undergraduate student involvement in Quantum optics research

SCHOOL OF NATURAL SCIENCES AND MATHEMATICS
The University of Texas at Dallas

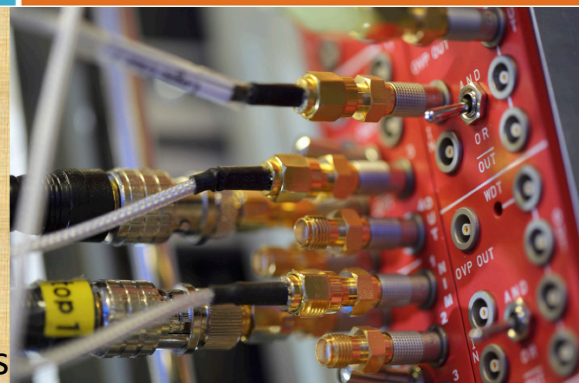
UT DALLAS



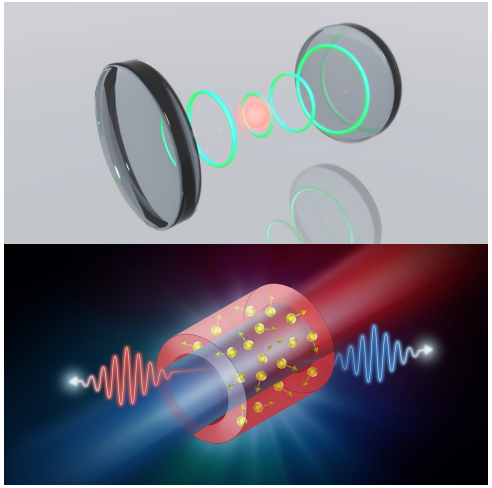
Du Group

Quantum Optics Lab

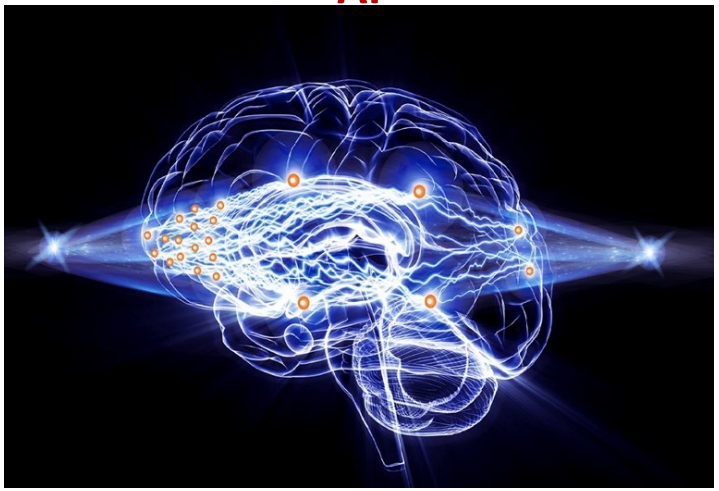
Department of Physics



Quantum Networks



Optical Neural Networks for AI



Optical Microscopy

PI: S. Du

Quantum Optics Lab @ UT DALLAS




Graduate Students


Undergraduate Students

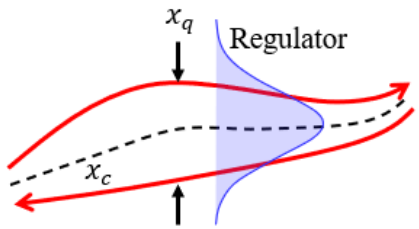
⟨$| NSF•DOE•AFOSR |$⟩

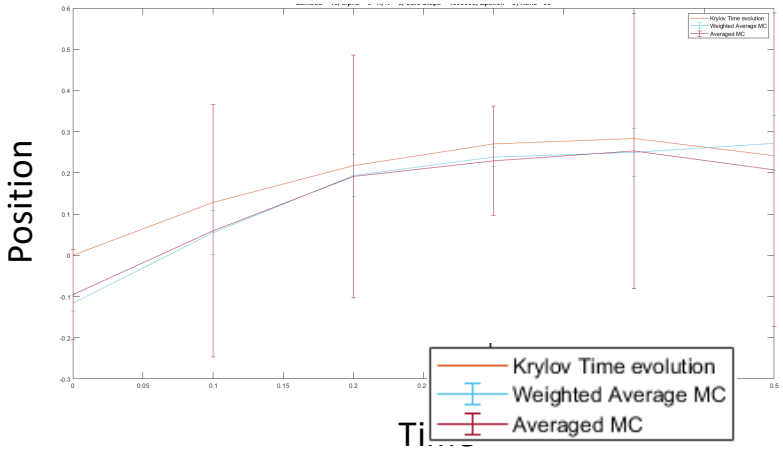
Undergraduate student involvement in Quantum research (Toward Quantum Computing)

Kolodrubetz group

In past 4.5 years, our group had
- 6 UTD undergraduates
- 2 REU students
We're always looking for good students

- Project #1: Simulating non-equilibrium quantum systems using a novel Monte Carlo path integral technique (2019-2020)
  - Patrick Koch, UTD senior. Current PhD student at UIUC
  - Write code to simulate system exactly for simple case
  - Develop codebase to compare to novel Monte Carlo method

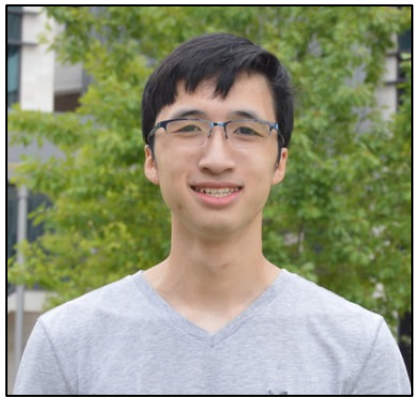


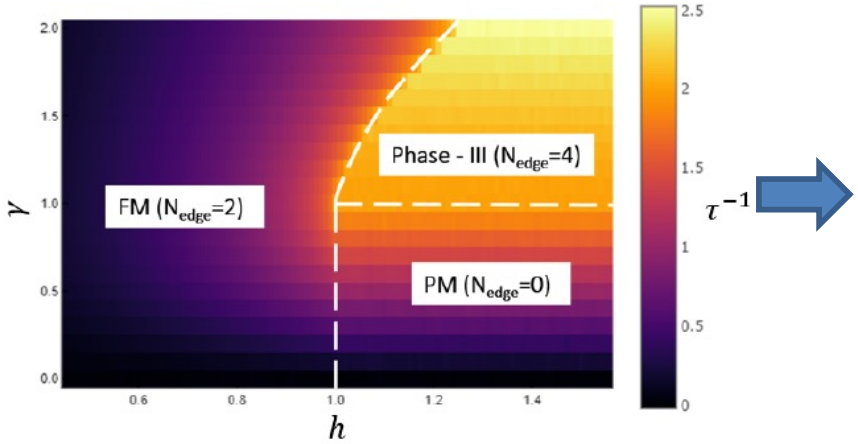


Kolodrubetz group

In past 4.5 years, our group had
- 6 UTD undergraduates
- 2 REU students
We're always looking for good students

- Project #2: Uncovering stable edge states in quantum spin system and simulating on quantum computer (2022-present)
  - Khoa Nguyen, UTD senior
  - Developing modified model and simulate classically to obtain phase diagram
  - Plan to implement on cloud quantum computer (IBM)





Undergraduate student involvement in

Cosmology and General relativity research

SCHOOL OF NATURAL SCIENCES AND MATHEMATICS
The University of Texas at Dallas

Testing General Relativity and Modified Gravity at Cosmological Scales

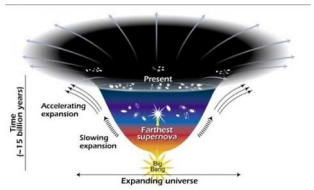
Orion Ning, UT Dallas REU 2020, Advisor: Dr. Mustapha Ishak-Boushaki

Goal: Constrain Modified Gravity (MG) Parameters Using Current Cosmological Data

Why test deviations from GR?

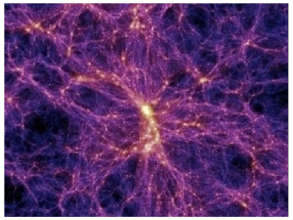
- Cosmic Acceleration ("Dark Energy") – Cosmological Constant or modification to GR (MG)?

$$G_{\mu\nu} + \Lambda g_{\mu\nu} = 8\pi G T_{\mu\nu}$$



Background:

- GR and Einstein's Field Equations gives equations governing universe's expansion dynamics – perturbations give growth equations to allow us to probe large-scale structure formation as source of observations



ISiTGR:
Integrated Software in Testing General Relativity

ISiTGR Version 3.1 released in February 2020

To probe modifications to GR, we use Modified Gravity parameters, which enter through growth equations

- We use (μ, η) (aka (μ, Ɣ)) and (μ, Σ) parameterizations

$$(k^2 - 3K)\Phi = -4\pi G a^2 \mu(a,k) \sum_i [\rho_i \Delta_i + 3(\frac{k^2 - 3K}{k^2})\rho_i(1+w_i)\sigma_i]$$

$$k^2(\Phi - \gamma(a,k)\Psi) = 12\pi G a^2 \mu(a,k) \sum_i \rho_i(1+w_i)\sigma_i$$

$$k^2(\Phi + \Psi) = -4\pi G a^2 \Sigma(a,k) \sum_i [3\rho_i(1+w_i)\sigma_i + \frac{2\rho_i\Delta_i}{1 - 3K/k^2}]$$

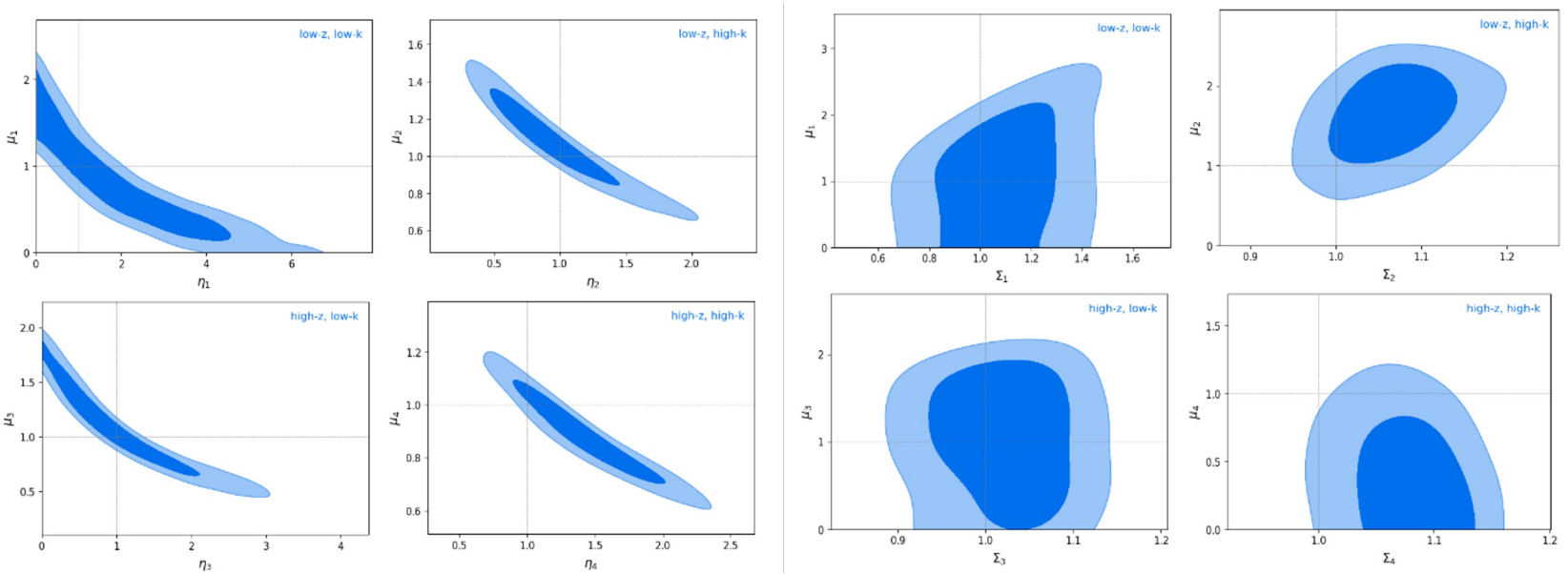
Method: Using ISiTGR (https://doi.org/10.1103/PhysRevD.100.103530 (Phys. Rev. D 100, 103530 (2019)))

- Allows constraints on MG parameters, and other features
- Involves CAMB/CosmoMC, which calculates cosmological parameters and samples them (via MCMC)

SCHOOL OF NATURAL SCIENCES AND MATHEMATICS
The University of Texas at Dallas

Planck 2018 Results and Analysis on Parameter Constraints

- Both functional form and binning forms implemented, binning results shown. Note, MG parameter = 1 implies GR



Conclusions: Overall, GR a valid theory that is mostly consistent with current cosmological probes. However, there are minor tensions with GR in binning results seen via constraints on MG parameters.

Main feature is Planck 2018 Cosmic Microwave Background (CMB) likelihoods;
Complementary data sets include:

- Dark Energy Survey (DES) Year 1 Clustering/Lensing Data
- Planck 2018 CMB Lensing Data
- Pantheon18 (Type Ia Supernovae)
- Baryon Acoustic Oscillations (BAO)
- Redshift Space Distortions (RSD)

Constraints for MG parameters using traditional binning in the (μ, η) parameterization							
μ_1	μ_2	μ_3	μ_4	η_1	η_2	η_3	η_4
$0.83^{+0.29}_{-0.74}$	$1.08^{+0.19}_{-0.17}$	$1.08^{+0.32}_{-0.41}$	$0.88^{+0.12}_{-0.14}$	< 2.76	$0.96^{+0.22}_{-0.42}$	< 1.35	$1.43^{+0.32}_{-0.41}$
Constraints for MG parameters using traditional binning in the (μ, Σ) parameterization							
μ_1	μ_2	μ_3	μ_4	Σ_1	Σ_2	Σ_3	Σ_4
$1.13^{+0.48}_{-0.95}$	$1.63^{+0.46}_{-0.35}$	$1.08^{+0.70}_{-0.51}$	< 0.553	$1.10^{+0.19}_{-0.19}$	$1.065^{+0.046}_{-0.052}$	$1.021^{+0.068}_{-0.055}$	$1.076^{+0.040}_{-0.031}$

Acknowledgements and thanks to: Dr. Mustapha Ishak-Boushaki, Cristhian Garcia-Quintero, Ganymede Cluster computations, UT Dallas Physics NSF REU Program and Funding

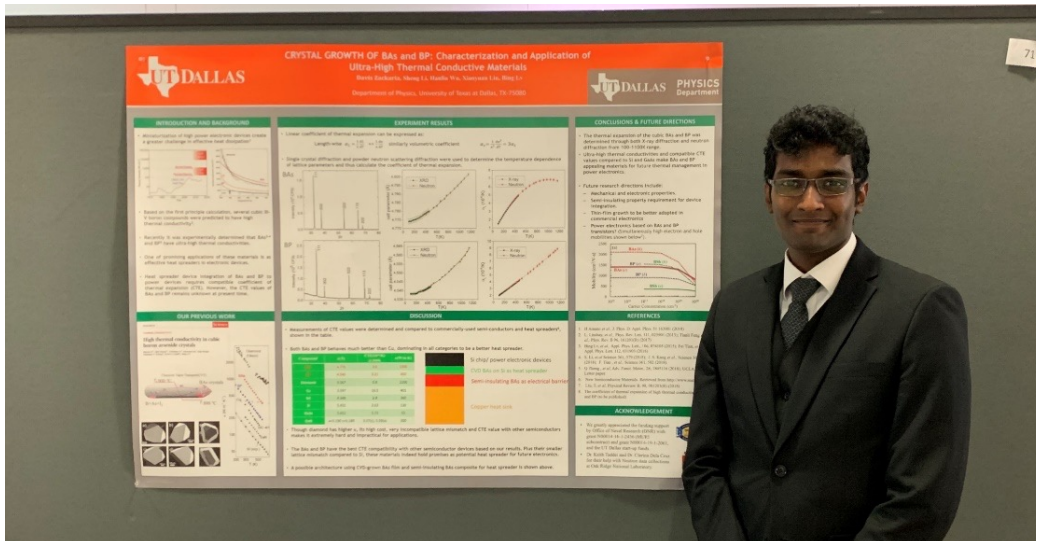
See more of this work on: https://doi.org/10.1088/1475-7516/2020/12/018 (JCAP 2012:018, 2020)

Undergraduate student involvement in Materials research

Undergraduate Students in Lv's Lab

- **All seven** undergraduate students received UTD **Undergraduate Student Research Award.**
- Two students (Varun Anand and Davis Zackaria) received **Undergraduate Student Poster Contest Award**.
- Two students (Chris Cailide and David Scherm) went to **Air Force Research Lab (AFRL)** for summer interns.

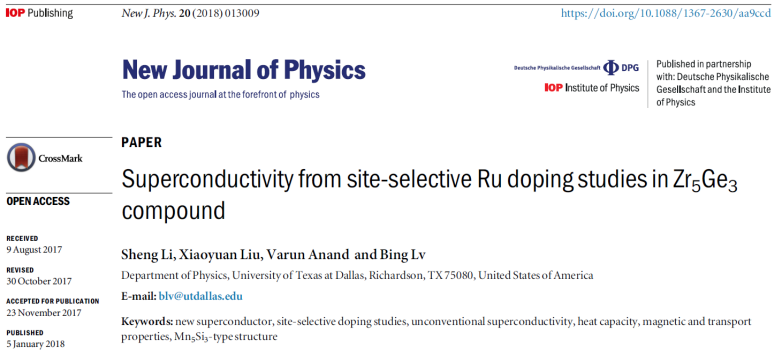
Varun Anand

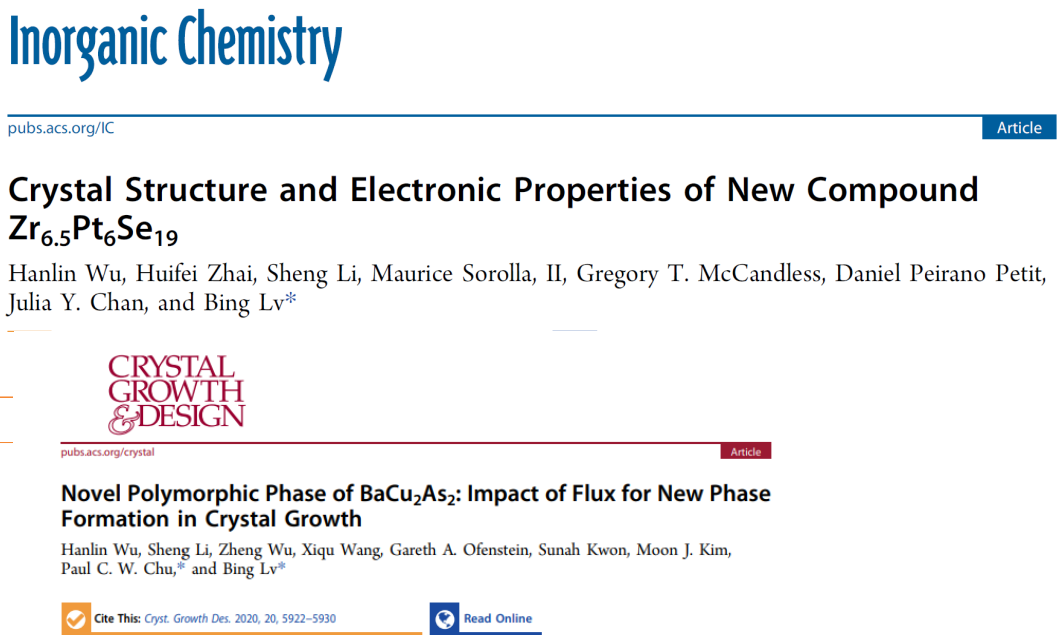


Davis Zackria

Undergraduate Students in Lv's lab

- **Six** undergraduate students have **at least one publication** with the group before graduation.
- One student was directly hired by Texas Instrument upon graduation. **All the rest all went to graduate schools** (received multiple offers from UC Davis, Ohio State, U. Colorado, Boston College, UIUC, UC San Diego, Arizona State, U Oklahoma etc).





Undergraduate student involvement in Plasma Physics research

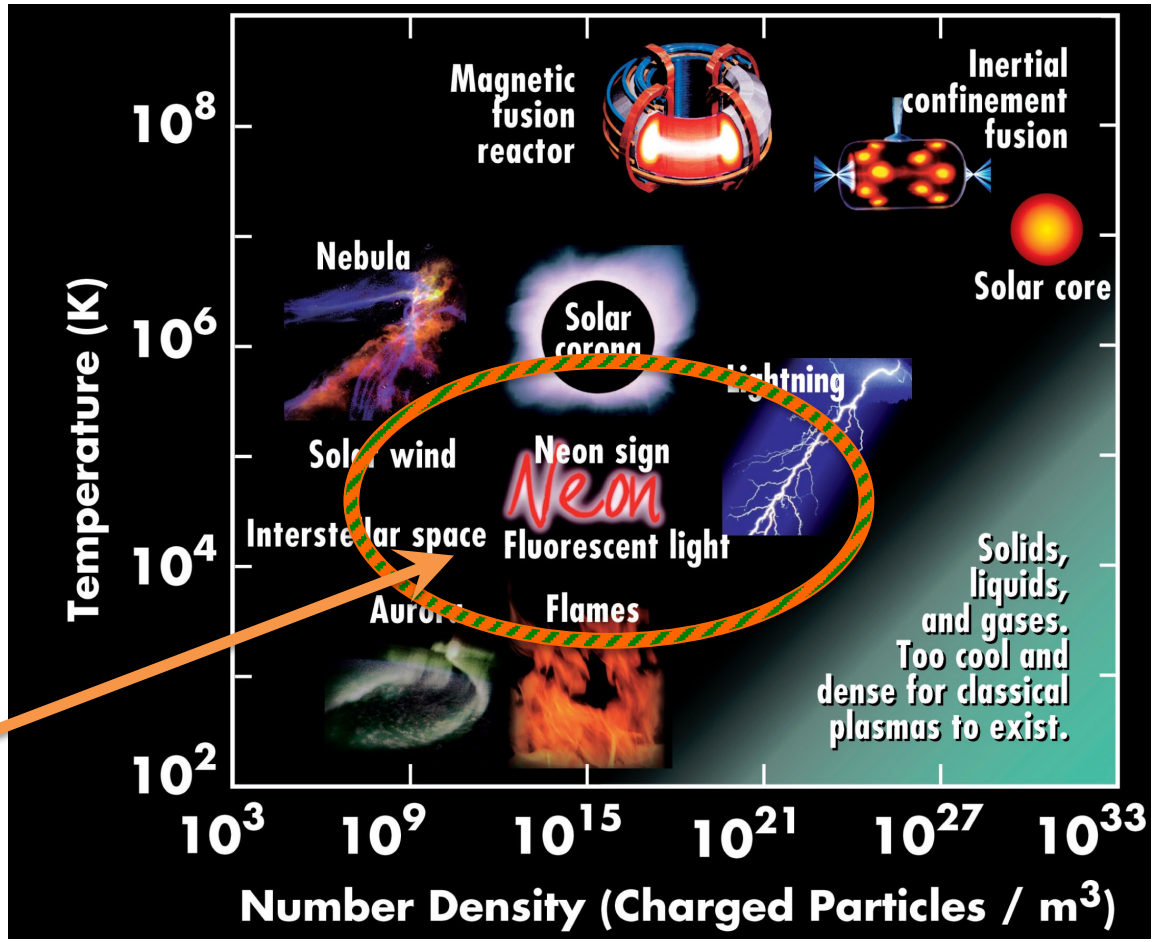
Plasma Physics

99% of the visible universe is plasma

- Stars
- Interstellar space
- Lightning
- Fire

Plasmas are WIDELY used in industry

- Arc welding/cutting
- Making computer ‘chips’
- Coating windows

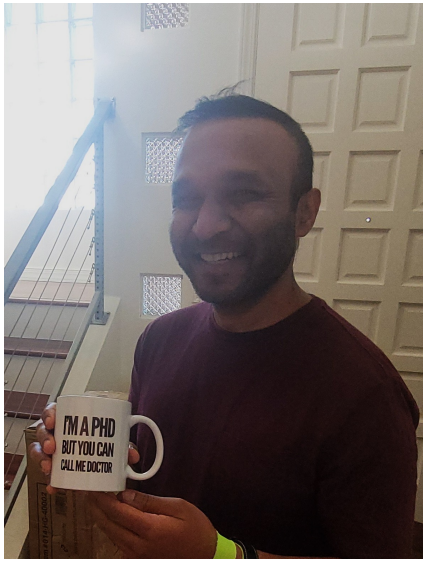


Undergraduate Students in Goeckner's lab

- 62 UG students have worked in his lab since 1999
  - 37 from UTD; 25 from other schools
  - 8 UG honors theses
  - 13 scientific publications in which UG students are authors.

- Some recent students have gone on to Princeton, Auburn and Georgia Tech
- 5 stayed at UT Dallas – receiving PhDs with Dr Goeckner.

Example Pathways



Ashish Jindal
WT White High School (DISD)
⇒ UT Dallas/Brookhaven
Current Employment: Sandia National Labs
Title: Principal Member of Technical Staff

Caleb Nelson
Prosper High School
⇒ UT Dallas
Current Employment: 3M
Title: Senior Research Specialist

David Urrabazo
Business Careers High School (San Antonio ISD - magnet)
⇒ UT Dallas
Current Employment: Tower Semiconductor Italy (TX)
Title: Test, device and yield engineer

Example Pathways

Gabriel Parron-Wells
Naaman Forest High School (Garland)
⇒ Richland College
⇒ UT Dallas
Current Employment: Samsung Electronics (Austin)
Title: Staff Engineer Process Integration

Keith Hernandez
Dallas Area High School
⇒ UPS / Odd Jobs
⇒ Collin Comm College (at 27)
⇒ UT Dallas
Current Employment: Applied Materials
Title: Physicist/Scientist

Questions?