Pathways in Physics
## Top Careers in Physics and Astronomy

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

## Employment outlook

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Employment - 2021</th>
<th>Projected Employment - 2031</th>
<th>Change, 2021-31</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Percent</td>
</tr>
<tr>
<td>Astronomers and physicists</td>
<td>25,200</td>
<td>27,200</td>
<td>+8%</td>
</tr>
<tr>
<td>Astronomers</td>
<td>2,200</td>
<td>2,400</td>
<td>+6%</td>
</tr>
<tr>
<td>Physicists</td>
<td>23,000</td>
<td>24,800</td>
<td>+8%</td>
</tr>
</tbody>
</table>
### Largest employers in Astronomy

<table>
<thead>
<tr>
<th>OCCUPATION</th>
<th>% OF TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research and development in the physical, engineering, and life sciences</td>
<td>41%</td>
</tr>
<tr>
<td>Colleges, universities, and professional schools; state, local, and private</td>
<td>24%</td>
</tr>
<tr>
<td>Federal government, excluding postal service</td>
<td>22%</td>
</tr>
</tbody>
</table>

### Largest employers in Physics

<table>
<thead>
<tr>
<th>OCCUPATION</th>
<th>% OF TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scientific research and development services</td>
<td>44%</td>
</tr>
<tr>
<td>Federal government, excluding postal service</td>
<td>15%</td>
</tr>
<tr>
<td>Colleges, universities, and professional schools; state, local, and private</td>
<td>12%</td>
</tr>
<tr>
<td>Ambulatory healthcare services</td>
<td>2%</td>
</tr>
</tbody>
</table>
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
UTD chapter of Society of Physics Students

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
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 GIANTIC galaxy!...

Galaxies moving under gravity during past 10 billion years!

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

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

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

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

Danny Eilbott
PhD Student @UC Berkeley, California
(High School Austin)
Undergraduate student involvement in

Biophysics
Research Interests

Biomolecular Simulations

Ionic Liquids AMOEBA-IL

Condensed Phase Simulations

Biomarker Discovery & Characterization

DNA/RNA Repair & Modification

Inorganic Catalysis

http://github.com/CisnerosResearch
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)

Undergraduate student involvement in
Quantum optics
Quantum Networks

Optical Neural Networks for AI

Optical Microscopy

Du Group
Quantum Optics Lab
Department of Physics
Quantum Optics Lab

@ UT DALLAS

Graduate Students

Undergraduate Students

⟨$| NSF\cdot DOE\cdot AFOSR |$⟩
Undergraduate student involvement in
Quantum
(Toward Quantum Computing)
Kolodrubetz group

- 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

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

- 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)

In past 4.5 years, our group had
- 6 UTD undergraduates
- 2 REU students
We’re always looking for good students
Undergraduate student involvement in Cosmology and General relativity
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)?

\[ G_{\mu\nu} + A g_{\mu\nu} = 8\pi G T_{\mu\nu} \]

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

To probe modifications to GR, we use Modified Gravity parameters, which enter through growth equations
- We use \((\mu, \eta)\) (aka \((\mu, \chi)\)) and \((\mu, \Sigma)\) parameterizations

\[
\begin{align*}
(k^2 - 3K)\Phi &= -4\pi G a^2 \mu(a, k) \sum_i [\rho_i \Delta_i + 3(\frac{k^2 - 3K}{k^2})\rho_i(1 + w_i)\sigma_i] \\
\frac{k^2}{2} (\Phi - \gamma(a, k) \Psi) &= 12\pi G a^2 \mu(a, k) \sum_i \rho_i(1 + w_i)\sigma_i \\
\frac{k^2}{2} (\Phi + \Psi) &= -4\pi G a^2 \Sigma(a, k) \sum_i [3\rho_i(1 + w_i)\sigma_i + \frac{2\rho_i \Delta_i}{1 - 3K/k^2}] 
\end{align*}
\]

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)
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.

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

Acknowledgements and thanks to: Dr. Mustapha Ishak-Boushaki, Cristhian Garcia-Quintero, Ganymede Cluster computations, UT Dallas Physics NSF REU Program and Funding
Undergraduate student involvement in Materials
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.
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
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 Comm College
**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
Example Pathways

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

**Gabriel Parron-Wells**
XXXX (DISD)
⇒ UT Dallas
**Current Employment:**
**Title:**
Questions?