

# THE UNIVERSITY OF ARIZONA ASTRONOMY & ASTROPHYSICS PHD PROGRAM

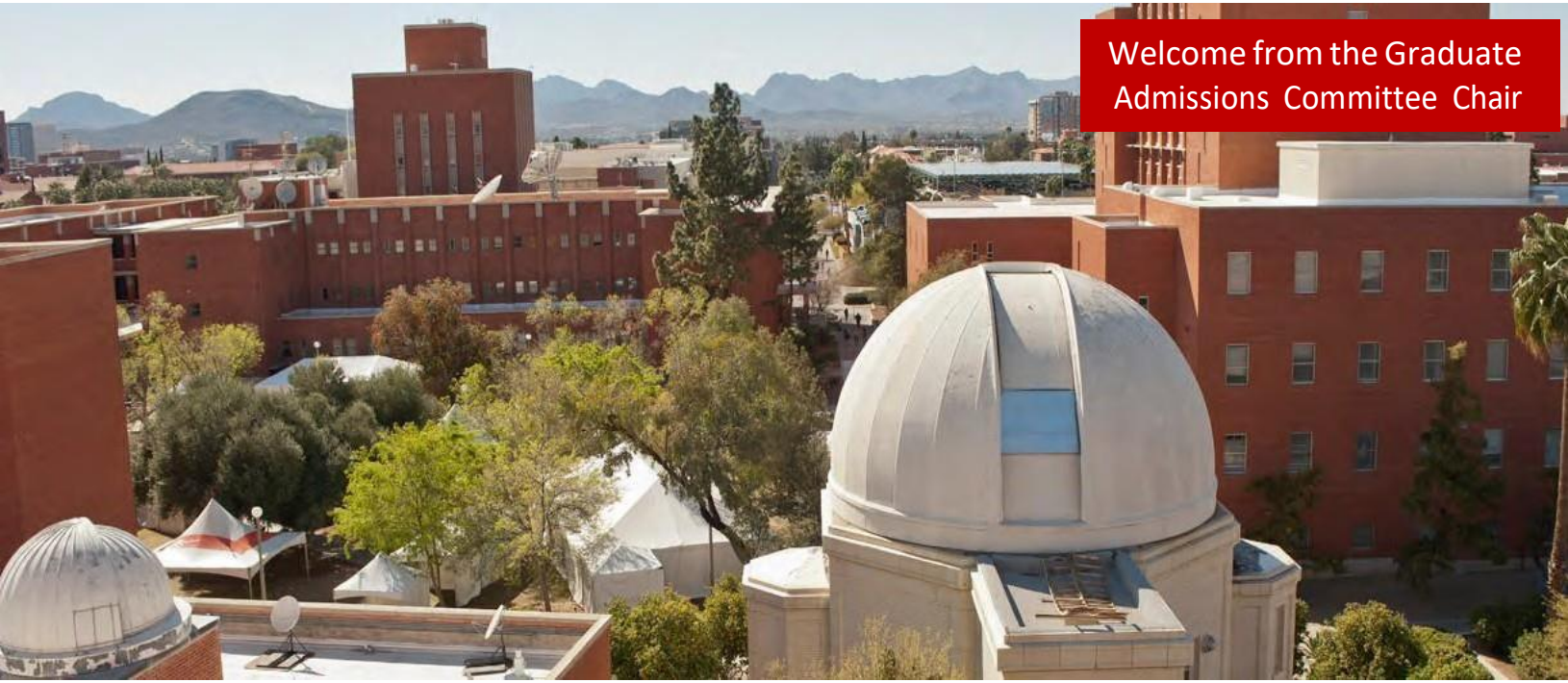


Department of Astronomy  
& Steward Observatory

[www.as.arizona.edu](http://www.as.arizona.edu)

# Inside

Welcome from Graduate Admissions Chair	3
How to Select a Graduate Program	6
Join Our PhD Program and Launch a Career in Astrophysics	7
An Inspiring Community Working on the Biggest Problems	8
A Research-Focused Program	9
An Unrivaled Suite of Telescopes	10
A Cutting-Edge Instrumentation Program	11
Theoretical Astrophysics on Powerful Supercomputers	12
Stars and Stellar Evolution	13
Extragalactic Astronomy and Cosmology	14
Star Formation and Astrochemistry	17
Exoplanets and Astrobiology	18
Financial Support, Startup Funds, and Living in Tucson	19
How Can You Apply?	20
International Applicants	20
Application Requirements and Procedures	21



Dear Applicant,

Thank you for your interest in the Graduate Program in Astronomy and Astrophysics at The University of Arizona. We are very proud of our graduate students and our Ph.D. program, one of the highest ranked programs in the country, according to the 2010 National Research Council assessment. The atmosphere of the Department is informal, friendly, and supportive, yet extremely active. Our large and diverse group of faculty, astronomers, postdocs, and graduate students pursue cutting edge research in theory, observation, and instrumentation. Our research ranges from compact objects to the formation of stars and planets, and the evolution of the Universe on the largest scales. As a Ph.D. candidate in our department, you will be trained in astronomical research at the highest level. You will depart from our department with the skills of a world-class scientist, prepared to be a leader in our field.

The department is led by a large (over 70 full-time) and accomplished faculty. We have four members of the National Academy of Sciences (Angel, Arnett, Kennicutt, G. Rieke, M. Rieke), two MacArthur Fellows (“Genius Grants”), including a 2012 winner (Guyon), and multiple winners of Kavli, Sloan, Packard, and Guggenheim fellowships. Several of our faculty have received the highest prizes awarded by the American Astronomical Society and American



**Assoc. Prof. Andrew Youdin**

Physical Society, including a 2020 winner of the APS Maria Goeppert Mayer Award (Elizabeth Krause). They are leaders in international collaborations and instruments, including two instruments for the James Webb Space Telescope.

The Astronomy department is a member of the interdisciplinary Theoretical Astrophysics Program (TAP), which involves the Physics, Astronomy, Planetary Sciences, and Applied Mathematics departments, as well as the National Optical Infrared Astronomy Research Laboratory, and includes more than 40 faculty affiliate members. Astronomy Department students do pioneer work on simulations and theory, including the astrophysics of stars, supernovae, nucleosynthesis, black holes, neutron stars, gravitational waves, galaxy formation, large-scale structure, and cosmology.



*“Our goals are to provide students with world-class resources and support, to fully realize their potentials, and to have them emerge as successful independent researchers, the leaders of the next generation.”*

The new University-wide Research Data Center provides our students access to high-end, local supercomputing resources (~400 TFLOPS) including distributed, shared-memory, and GPU architectures. Our department is also the lead institution in NASA’s Nexus for Exoplanet System Studies (NExSS) and home to an interdisciplinary team of 25 faculty and 13 students and postdocs studying habitable exoplanet formation.

Our Center for Astronomy Education is among the nation’s leading science education research groups. At our department you will also have the opportunity to minor in Astrobiology, Physics, Planetary Sciences, or Optical Sciences to better prepare for the challenges that motivate you the most.

You will have direct access to world-class facilities for ground-based optical, infrared, and submillimeter observational astronomy, and have the opportunity to be involved in major space astronomy and astrochemistry projects. Current facilities include the 2x8.4m Large Binocular Telescope, the 6.5m MMT, the twin 6.5m Magellan telescopes, the 10m Heinrich-Hertz Submillimeter Telescope, the Kitt Peak

12m mm-wave Telescope, the 2.3m Bok and 1.5m Kuiper telescopes, and the 1.8m Vatican Advanced Technology Telescope.

Steward Observatory is also a leading partner in the development of the 24.5m Giant Magellan Telescope in Chile, and of the award-winning Event Horizon Telescope. Survey science is facilitated by full membership in the SDSS and DESI consortia as well as through our active research programs in the Vera Rubin Observatory’s LSST science collaborations, and the NASA SPHEREx and Nancy Grace Roman Space Telescope missions.

These activities are complemented by world-class programs in instrumentation, including the Center for Astronomical Adaptive Optics, construction, and scientific leadership of NIRCam and MIRI instruments for JWST, as well as optics and instrumentation for all of our observing facilities including the future Giant Magellan Telescope.

In our program you will enjoy an academic environment with a rich history in astronomy and international prestige. Our graduate program was established in 1927 and in the past nine decades about 250 astronomers earned their PhD at The



University of Arizona, making our program one of the largest in the country. Our graduates have been extremely successful: We rank among the top institutions in winning prestigious Hubble Fellowships upon graduation, including seven winners in the last 5 years and 24 over the life of the program. Many of our graduates have gone on to prestigious professorships or similar positions of leadership within the astronomy community. The department is committed to developing excellent and diverse professional scientists through its Ph.D. program. Women and other underrepresented minorities have had a strong history of success in our program and are especially encouraged to apply. We welcome applications from

undergraduates in astronomy and related sciences, including physics, mathematics, computer science, engineering, chemistry, and biology, who excited to can take advantage of this unique environment.

I encourage you to review our website for further information. Applications are accepted online; please see the application procedure outlined at the end of this booklet. Applications received by December 4, 2023 will be given full consideration. Please feel free to contact me if I can be of assistance.

With best wishes to your future scientific journey,

Assoc. Prof. Andrew Youdin  
2023-2024 Graduate Admissions Chair



*Current Steward graduate students below the orange trees in the Steward Backyard*



*“As a graduate student at Steward, I not only had access to some of the biggest telescopes in the world for my research, but also a community of astronomers who still have the same enthusiasm about understanding the universe as when they were kids; my curiosity was constantly fed!”*

- Johanna Teske, 2014 PhD, now Staff Scientist at the Carnegie Observatories

You are about to make an important decision. While the University of Arizona provides great opportunities in astronomy, your job is to find the school where you will flourish and do the kind of science that will open opportunities for you.

## How to Select a Graduate Program

Here are four suggestions to help you think through the decision:

No one graduate school is so much better than the rest that it becomes your only logical choice. All the very top programs in the United States are excellent, and you will do well if the fit is good. A degree from any good program can open doors for a successful career in astronomy. You are selecting where you are going to live, think, and play for the next 4-6 years. If you are unhappy, graduate school is not worth the considerable effort required from you.

It is good to consider the totality of educational opportunities in the surrounding community, not just the specific graduate program. Are there related departments at the same university? Does the community contain major additional astronomy centers that might be options for your research, as well as enriching the general academic environment in astronomy? How do the interests of the faculty align with your scientific interests? What facilities are available for you to conduct your research? To what share of those facilities will you have access?

At the same time, what is the breadth of related

activity? For example, if you are heading into observational astronomy, it might be beneficial to be at a place that builds instruments even if you do not plan to do that, as it would broaden your perspective. If you are interested in theory, a vigorous observational program would surround you with people for whom your work could provide insight and who could suggest ways to test your ideas. Try to avoid single point failures; that is, be sure there are enough faculty members in your area(s) of interest that your success does not depend entirely on one of them.

Think strategically and long-term: You are not only selecting a program for the next few years, but you are also choosing your next steps in becoming an independent researcher and setting your course in a competitive field. Many programs offer short-term advantages or perks, such as a laptop or a named fellowship, while other programs may provide access to better courses, stronger faculty, or rare resources. Good luck in your decision, and by all means come visit us to judge how we measure up for you!

**How to Apply? See page 20!**





UA members of two different projects take a break at the South Pole: Former Graduate students Junhan Kim and David Lesser, and UA faculty Dan Marrone and Craig Kulesa are developing new telescopes in Antarctica

# Join Our PhD Program and Launch a Career in Astrophysics

There are many reasons why The University of Arizona’s Astronomy and Astrophysics Graduate Program is among the top US astronomy programs, including the following:

- A distinguished and active faculty, including four members of the National Academy of Sciences and winners of Kavli, Sloan, Packard, MacArthur, Guggenheim, American Astronomical Society, and American Physical Society fellowships and prizes
- Access to world-class large, medium, and small-aperture telescopes for millimeter, infrared, and optical wavelengths
- A broad and vigorous program in theoretical astrophysics, with more than 20 faculty members drawn from Astronomy, Physics, Applied Mathematics, Lunar and Planetary Sciences Departments, and NSF's National Optical-Infrared Astronomy Research Laboratory.
- Leadership in the key astronomical observatories of the next decade, including the Large Synoptic Survey Telescope, the James Webb Space Telescope, and the Giant Magellan Telescope.
- Innovative telescope and instrumentation research groups, including the SO Mirror Lab, the Center for Astronomical Adaptive Optics, the Imaging Technology Lab, Infrared Detector Lab, and three radio instrumentation labs.
- Extensive supercomputing resources, including access to the latest GPU’s.
- One of the largest astronomical communities with the Department of Astronomy, the Lunar and Planetary Laboratory, NSF's National Optical-Infrared Astronomy Research Laboratory, and the Planetary Science Institute.
- One of the largest and strongest exoplanet communities and lead institution of the NASA- funded Earths in Other Solar Systems (EOS) research consortium.
- Steward Observatory and Lunar and Planetary Laboratory are often ranked #1 in the US by NSF in research expenditures in space sciences.

# An Inspiring Community Working on the Biggest Problems

With over 400 employees, the Department of Astronomy, Steward Observatory, and affiliated units are one of the largest institutions dedicated to astronomical and astrophysical research. More than twenty large research groups within the Department focus on major research topics, covering essentially all major research areas from the very high redshift universe to the smallest exoplanets.

In a typical week at the Department, you will have the opportunity to attend any of the 15 to 20 seminars, colloquia, astro-ph coffees, afternoon teas, and journal club talks. Several of the corridors have strategically placed whiteboards and you will often find ad hoc groups of students and faculty discussing research questions or ideas in the corridors, in the library, or in one of the interaction areas. Beyond all the activity in the Department, there is a large and vigorous astronomical community in the Tucson area. The University's Lunar and Planetary Laboratory/Department of Planetary Sciences, the College of Optical Sciences, as well as the headquarters of the NSF's National Optical-Infrared Astronomy Research Laboratory, are located just across the street from Steward.

Our students often work with faculty and staff from these organizations and attend the steady stream of talks and meet the visiting astronomers from around the world.



*"I really enjoy working in a large department. I've learned a lot from people outside of my primary research focus, and from visitors coming through Steward and the OIR Lab across the street."*

*Decker French, Former Ph.D. 2017, Faculty at University of Illinois & Trumpler Award Winner.*

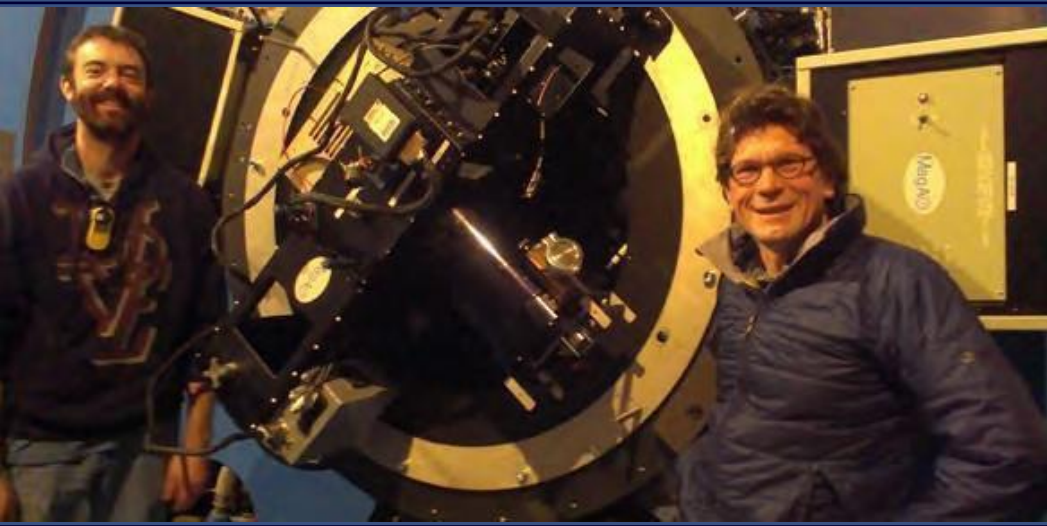
---

The University of Arizona's Department of Astronomy and Steward Observatory (SO) is a leading astronomical research organization and home to a large and active graduate program in Astronomy and Astrophysics. Our Ph.D. program provides an outstanding intellectual environment that fully prepares students for a productive career in astronomy, and it is among the highest ranked programs in the country according to the 2010 National Research Council assessment.

Our observational and theoretical research addresses every wavelength and field, from exoplanets to cosmology, and is supported by the active development of astronomical instrumentation for ground- and space-based observatories. Graduate students are supported for the duration of the typical Ph.D. period and are central to the scientific environment of the department.

We are proud of the achievements of our graduates, with 70% of our graduates in the last decade holding astronomy-related positions, and with many having been accorded honors. We rank among the top institutions in winning prestigious Hubble Fellowships upon graduation, including seven awardees in the last 5 years and 24 over the life of the program. This is the result of both our selective admissions procedure, and the energy and resources that we devote to graduate education.





Planet hunters UA faculty members Jared Males (left) and Laird Close at the Magellan telescope in Chile with the UA-developed MagAO adaptive optics system.

# A Research-Focused Program

Our graduate program strongly emphasizes active research. When admitted to our program you will be invited to visit the campus and meet with the many research groups at the Department. Most students select a research topic and join a research group at the beginning of their first semester and continue to be immersed in research throughout their studies.

In the first two years in our program, you will take a set of courses that will provide you with a combination of robust foundation and introduction to cutting-edge topics; but the course load is designed in such a way to allow active research in parallel with the courses.

Most of our students publish at least one first author refereed paper by the end of their second year.

After their fourth semester most of our students fully focus on their research projects, but some decide to take on additional courses to specialize on certain topics, such as out-of-department courses offered by the Department of Planetary Sciences, the College of Optical Sciences, or the Department of Physics.



*“One thing I really enjoyed about Steward is the emphasis placed on research. Students begin their projects during the first semester and the program is set up such that we can focus on research and classes or research and teaching, but rarely all three at the same time.”*

- **Carolyn Raithel**, 2020 Ph.D. and Postdoctoral Fellow at the Institute for Advanced Study at the Princeton Center for Theoretical Science



At UA you will have direct access to at least sixteen research telescopes. Among these are radio telescopes (left), the 6.5m MMT, the 2x8.4m LBT (right), and the twin 6.5m Magellan telescopes in Chile.

## An Unrivaled Suite of Telescopes

All our telescopes are accessible to our graduate students. We allow students to apply for telescope time without faculty collaboration. Our facilities – many of which are close to Tucson – include the 6.5-meter MMT telescope with state-of-the-art instrumentation for wide-field surveys and adaptive optics, the 6.5-meter Magellan I & II telescopes in Chile accessing the Southern Hemisphere sky, and the Large Binocular Telescope, one of the world's most advanced optical telescopes. Its two 8.4-m mirrors provide the same light gathering ability as a 11.8-m single mirror telescope and a spatial resolution equivalent to a 22.8-m telescope.

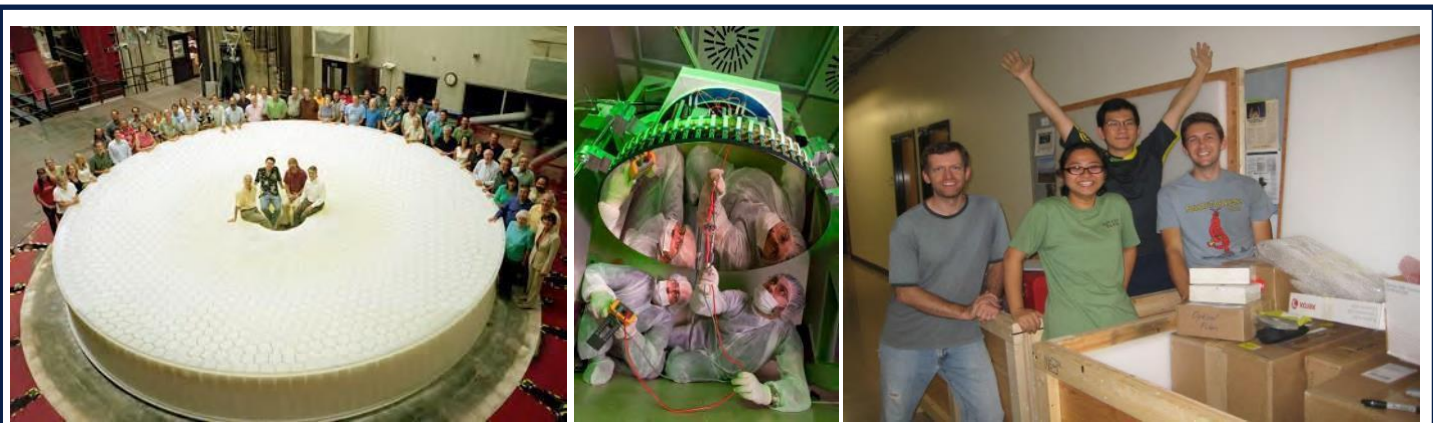
We also manage the Arizona Radio Observatory, consisting of the 10-m Submillimeter Telescope on Mt. Graham and an ALMA prototype antenna on top of Kitt Peak, making us one of the few departments with direct access to millimeter- and submillimeter-wavelength facilities. Steward Observatory also operates smaller telescopes on Mt. Lemmon and Kitt Peak, which also do forefront research owing to high-quality instrumentation that is engineered at the Observatory.

Steward faculty and students also lead many large-scale surveys on space telescopes, including Hubble, Spitzer, Chandra and Herschel. Infrared instruments onboard the upcoming James Webb Space Telescope developed by teams led by Steward faculty offer exciting new opportunities to address many of the most important astrophysical questions with new and powerful instruments.



“At the UA, I conduct my research in an environment with countless world-class astronomers who are friendly, encouraging, and eager to collaborate.”

Nick Ballering, Ph .D . 2017, now  
*Postdoctoral Fellow at University of Virginia.*



Left: Celebration of the new LSST mirror at the UA's Caris Mirror Lab. Middle: Testing of a deformable secondary mirror for the Large Binocular Telescope. Right: Receivers packed for the South Pole Telescope.

# A Cutting-Edge Instrumentation Program

Steward supports forefront instrumentation development in many areas, involving many students. The Richard F. Caris Mirror Lab produces the giant mirrors needed for major observatories, including Magellan, LBT, the Large Synoptic Survey Telescope, and the Giant Magellan Telescope.

The Center for Astronomical Adaptive Optics is developing and deploying the systems needed to achieve diffraction-limited performance from large ground-based telescopes. Key technologies are being developed and applied on-sky to directly image Exoplanets at the LBT and Magellan telescopes. These are often student led projects. State of the art submillimeter receivers are built and deployed by the Steward Observatory Radio Astronomy Laboratory (SORAL) and the Arizona Radio Observatory. Steward faculty has led the development of some of the most powerful infrared instruments for space telescopes, including NICMOS for the Hubble Space Telescope, MIPS for the Spitzer Space Telescope. The upcoming James Webb Space Telescope's NIRCAM instrument was built by a team led by Steward faculty Marcia Rieke and the MIRI instrument, which was developed by a team whose U.S. lead is Steward faculty George Rieke. Funded by various NASA grants our faculty and student teams are constantly developing novel technologies and ideas for new space missions and instruments.

Graduate students are involved in essentially all projects, often receiving major responsibilities in instrument development, testing, and operations. Our students regularly travel across the globe to use their specialized instruments to answer major questions in astrophysics — in any given semester you may find them launching balloon-born telescopes from Antarctica, working on space instrumentation at UA or NASA laboratories, working on adaptive optics technology in Italy, operating instruments in the Atacama Desert, observing at our Arizona observatories, in European observatories, or atop Cerro Las Campanas in Chile.



*"As a graduate student, I was able to lead my own observational projects and tinker with instruments in a way that is not possible anywhere else."*

- Andrew Skemer, 2012 UA PhD, Former Hubble Fellow & UC Santa Cruz Assistant Professor





Credit: K. Kratter, G. Besla, E. Schneider

Sample simulation results on disk-planet interactions, galaxy collision, Kelvin-Helmholtz instability. UA faculty Kaitlin Kratter explains planet formation theory in a BBC documentary.

# Theoretical Astrophysics on Powerful Supercomputers

The Astronomy department is a member of the interdisciplinary Theoretical Astrophysics Program, which unites members of the Physics, Astronomy, Planetary Sciences, and the Applied Mathematics departments and NSF's National Optical-Infrared Astronomy Research Laboratory and includes more than 40 faculty. The new University-wide Research Data Center provides our students access to high-end, local supercomputing resources (~400 TFLOPS) including distributed, shared- memory, and GPU architectures.

Key research topics in the Astronomy department's theory groups include galaxy evolution and mergers, the distribution of satellite galaxies and formation of tidal streams, cosmological structure formation, local group dynamics, near field cosmology, physics of compact objects, supernovae, star and planet formation.

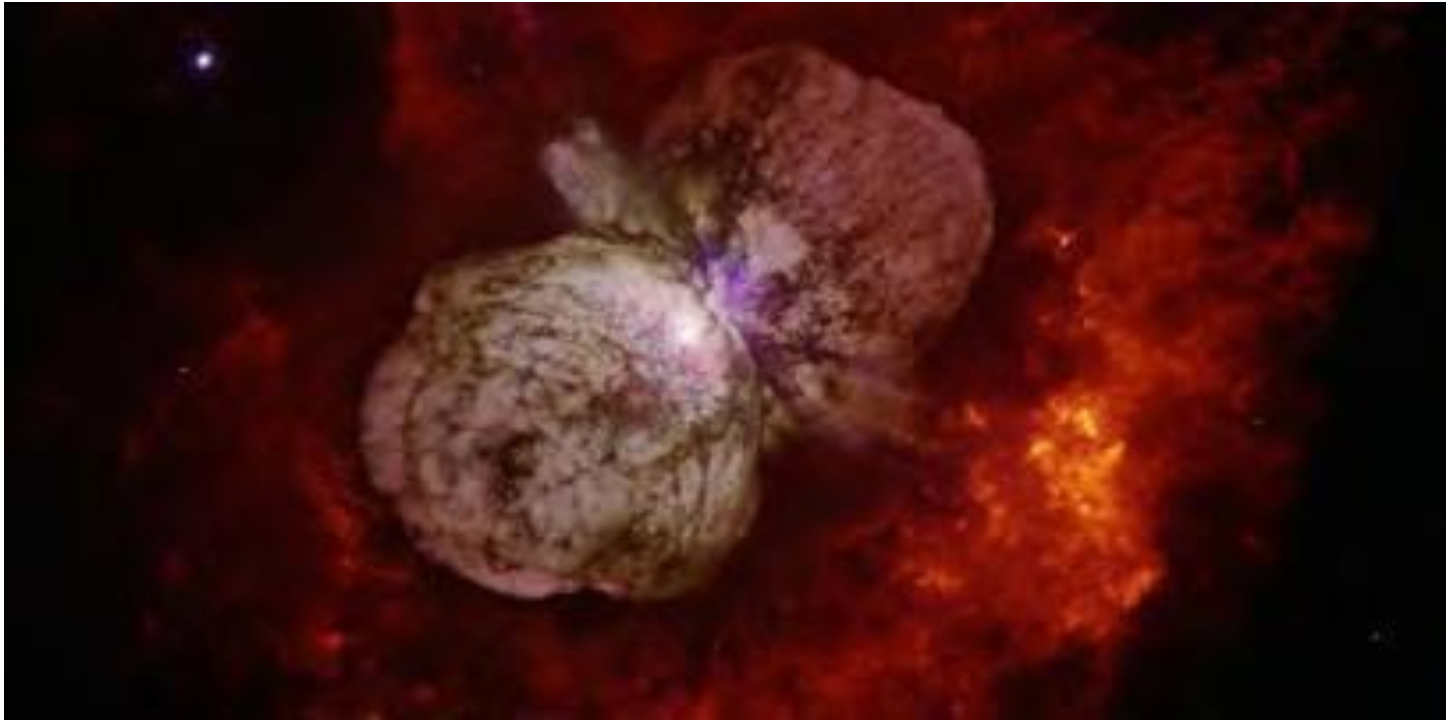
Our graduate students have the opportunity to write code for new accelerator technologies on the state-of-the-art El Gato, Ocelote, and Puma High-Performance computing clusters at UArizona.

Former Graduate student Evan Schneider (now a Hubble Fellow at Princeton) used his own gpu-based hydrodynamics code, CHOLLA, to create the above pictured ultra-high-definition image of developing Kelvin-Helmholtz instabilities in a high-resolution fluid simulation. These new accelerator technologies allow students to run simulations at speeds of 10 to 50 times that of a traditional CPU cluster.



*“One of my favorite things about Steward is the community; upon arrival, I instantly felt welcomed by the faculty and my peers, all of whom I had ample time to talk to and get to know during my first few weeks through a number of events specifically geared towards new students settling in and becoming a part of the community.”*

- David Ball, 5th year graduate student



*UA faculty Nathan Smith is coordinating a major research initiative on the massive star eta Carinae and its environment, seen here in a Hubble Space Telescope image.*

## Stars and Stellar Evolution

Steward Observatory has an active program of research in stars and stellar evolution, as well as the explosive transient sources that accompany the deaths of stars. Both theoretical and observational efforts are underway, and stellar theorists and observers have lively interactions with one another.

Theoretical efforts have concentrated on fundamental questions in stellar evolution, such as computing the complex and detailed multidimensional effects of turbulent convection. This emphasizes the unstable late stages of massive star evolution and their connection to the eventual core collapse supernova, as well as the physics of supernova explosions themselves.

Observational work on stellar astrophysics utilizes Steward Observatory's unprecedented access to a diverse suite of large and small ground-based telescopes in order to conduct optical and infrared studies of various types of stars and transient sources,

and these projects often include a number of space-based facilities as well for access to ultraviolet and far-infrared wavelengths or high angular resolution.

Areas of particular emphasis are spectroscopy of various classes of evolved stars, high angular resolution studies of circumstellar material around massive stars, dust production by massive stars and supernovae, studies of massive binary systems and their evolution, stellar kinematics, and time-resolved studies of explosive transients such as eruptive massive stars, thermonuclear and core-collapse supernovae, and gamma-ray bursts. Steward researchers also conduct observational studies of the host galaxy environments of massive stars and various types of explosive transients, and they obtain and analyze spectropolarimeter of supernovae to investigate the geometry of these explosions.

There is a large and growing group working on time-domain astronomy, including gravitational wave follow-up.



*UA Faculty Ann Zabludoff and former graduate student Decker French study stars that pass too close to a galaxy's central, supermassive black hole and are tidally disrupted.*

## Extragalactic Astronomy and Cosmology

Steward Observatory has a broad, ambitious program in extragalactic astronomy and cosmology, combining theory, observations, and instrumentation to study the formation of structure in the Universe from the scales of individual galaxies to the cosmic microwave background radiation. Research opportunities are available with 20+ faculty and research staff and include investigating the formation of the first stars and galaxies, how black holes evolve and influence the evolution of their host galaxies, and the nature of dark matter and dark energy. The extragalactic community at Steward is large and interactive, with numerous graduate students, post-doctoral researchers, and faculty collaborating with each other and with members of the on-site Vera Rubin Observatory project headquarters, NSF's OIR Lab, and UA Physics department.

Research spans topics ranging from gamma-ray bursts to X-ray powerful AGN to UV-emitting tidally disrupted stars to optical/infrared-bright star-forming galaxies to radio-detected galactic molecular gas reservoirs and young galaxy clusters. Theoretical efforts include modeling the dynamics of the Local Group, extending gravitational lensing theory to multiple lensing planes, modeling the evolution of supernovae used as cosmological standard candles, and predicting the

shadows cast by supermassive black holes in the centers of galaxies. Observational work includes studies of dark matter using dwarf galaxies, the star formation and chemical enrichment history of the Universe, the period of cosmological re-ionization, the lowest surface brightness galaxies, the distant Universe through gravitational lensing, galaxy clusters with the Sunyaev–Zel'dovich effect, and the detailed transformation of galaxies from star-forming disks into quiescent spheroids. The recent imaging of the Galaxy's supermassive black hole with Event Horizon Telescope involved leadership and participation of many Steward staff and students.

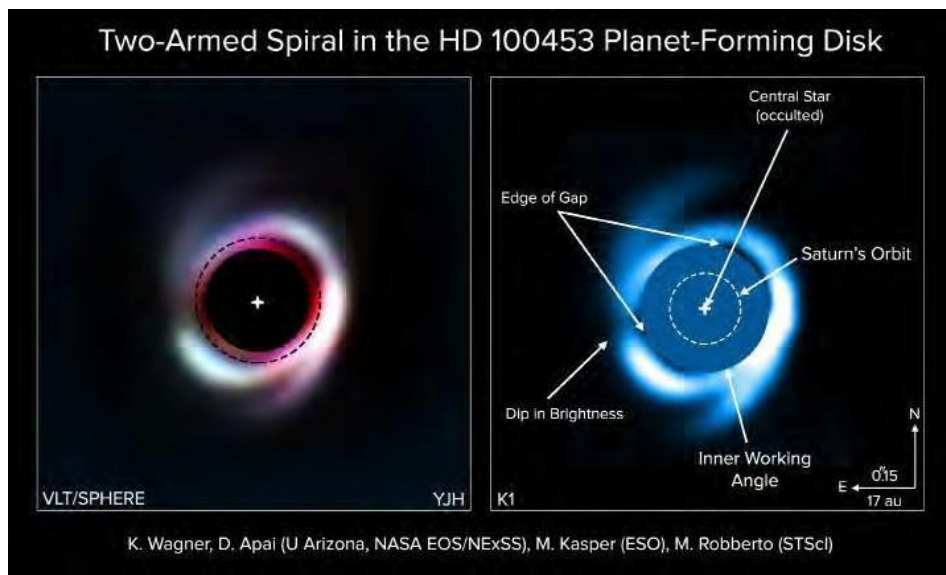
Instrumentation projects include the design of principal instruments for space missions such as the James Webb Space Telescope, development of new submillimeter receivers for telescopes as far afield as at the South Pole, design and construction of terahertz receivers flown on balloon-borne platforms, and upgrades of existing instruments such as the SPOL imaging spectra-polarimeter on the 6.5m MMT telescope.

The extragalactic community at Steward is an active user of the Observatory's state-of-the-art observing and computational facilities.





*Infrared image from the WISE satellite shows galactic star-forming regions strongly affected by young massive stars. UA faculty Serena Kim is studying how massive stars evaporate disks around other young stars, affecting their member for planet formation.*



*Steward 2020 PhD and now NASA Sagan Fellow Kevin Wagner used extreme adaptive optics images to probe the environment of the young star HD100453 and discovered a rare two-armed spiral structure and imaged a gap, possibly formed by a giant planet.*



# Mapping the Large-Scale Structure

Faculty at Steward Observatory are deeply involved in a variety of ground-based surveys and space-based missions that map large fractions of the sky. We have access to existing data from the Dark Energy Survey and the Dark Energy Spectroscopic Instrument and are deeply involved in shaping the science strategy of near future endeavors such as the Rubin Observatory’s Legacy Survey of Space and Time, the NASA SPHEREx explorer mission (launch ~2024) and the NASA Flagship Roman Space Telescope (launch ~2025).

Our research groups collaborate closely with the Physics department and the Data Science Institute (Data7) on modeling of cosmological observables, data analysis of large survey data sets and forecasting of the science return of future missions. Faculty and students have access to a variety of Super-Computing resources, e.g. the local UArizona “ocelote” and the newly operational “puma” system, as well as several

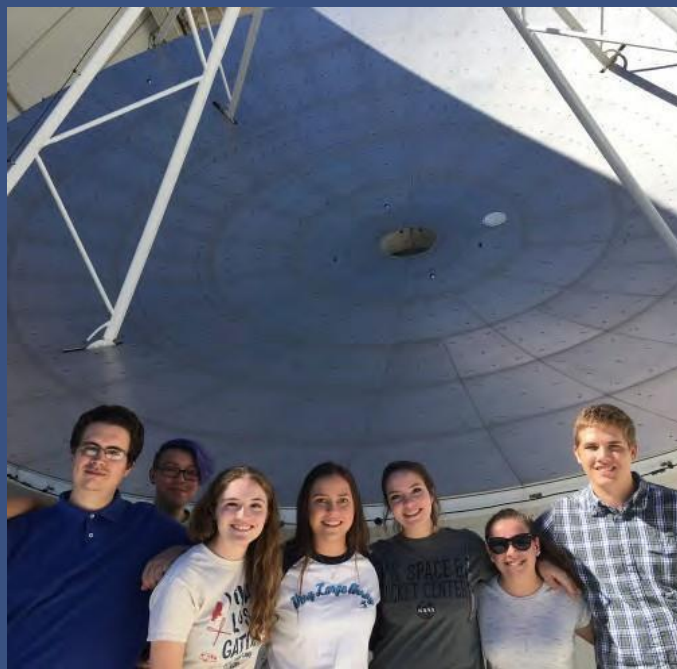
National Super-computing resources.

Students have access data and simulations from these surveys and work with faculty on designing their individual projects to be conducted in small teams or within large survey collaborations. These projects range from pen and paper theory calculations, modeling cosmological observables on super-computers, to full scale cosmological data analysis to constrain fundamental physics in the Universe.



*The Puma and Ocelote High-Performance Computing resources are used for the science analysis of large survey data and for the science optimization and forecasts of future mission.*





Working with UA faculty Yancy Shirley, the undergraduate students in the UA Astronomy Club are observing galactic star-forming cloud cores at Kitt Peak National Observatory with the Arizona Radio Observatories ALMA Prototype Antenna.

## Star Formation and Astrochemistry

Steward Observatory is leading a suite of projects that focus on understanding the formation of stars and their impact on the physics and chemistry of the interstellar medium and molecular clouds.

Based on powerful datasets – taken at wavelengths from X-rays to radio – we explore the characteristics of young stellar and sub-stellar objects as well as their circumstellar material. Our research projects approach key questions in star formation both observationally and theoretically.

Many of our star formation studies build on our unique telescope access, such as MMT, Magellan, LBT, UKIRT, Bok, and Arizona Radio Observatory telescopes located in Arizona and Chile. We also use other community telescopes, such as the ALMA millimeter interferometer, and the Chandra, Spitzer, Herschel, and Hubble Space Telescopes. Our groups are gearing up to use the upcoming powerful James Webb Space Telescope, two key instruments of which have been built by teams led by UA faculty Marcia Rieke and George Rieke.

Key research projects related to star formation include topics such as probing the role of UV radiation on young stars and their circumstellar disks in vicinity of massive stars, initial mass function as a function of star-forming environment and age, accretion and circumstellar disk properties, and occurrence rate and evolution of very low mass brown dwarfs and unbound planets.

Steward faculty is also leading an extensive set of observations and laboratory studies to characterize the chemical evolution of the interstellar medium, molecular clouds, and pre-stellar cores. The observations use the Arizona Radio Observatory's powerful telescopes at the Mt. Graham and Kitt Peak observatories.

UA professor Lucy Ziurys's radio spectroscopy laboratory carries out extensive radio spectroscopic surveys of giant molecular clouds, comets, and environments of evolved stellar envelopes. UA faculty Chris Walker is leading a NASA balloon mission, GUSTO, that will study the life cycle of interstellar gas in our Milky Way.



# Exoplanets and Astrobiology

Exoplanets and astrobiology research have a decades long tradition at Steward Observatory. Currently, Steward, LPL, and NSF's OIR Lab astronomers form what is probably the largest community of exoplanet researchers in the United States, with groups covering essentially every aspect of exoplanet formation, discovery, characterization, and habitability.

Our major exoplanets and astrobiology projects include:

The NASA-funded Large Binocular Telescope Interferometer, a major unique instrument developed to study exoplanets and dust disks exploiting the 22.8m LBT telescope.

The NASA-funded Earths in Other Solar Systems is a major research program aiming to understand how and where habitable, earth-like planets with biocritical ingredients (volatiles and organics) form. It involves over 40 faculty, postdocs, and students, and it is one of the largest programs within NASA's NExSS exoplanet research network.

Powerful Steward faculty led instruments and guaranteed time programs on the James Webb Space Telescope will explore planet formation and exoplanet atmospheres.

The NSF-funded MagAO instrument and associated research programs exploit a new extreme adaptive optics system on the Magellan telescope to discover new planets and study disks.

Nationwide interdisciplinary research is emerging as a new, powerful approach to some of the most exciting scientific challenges; but few schools can offer a broad enough foundation to position well young scholars for interdisciplinary research. The University of Arizona is among the very few institutions that offers a formal, well-planned PhD minor degree in astrobiology.



*This lecture is part of a series of exoplanet lectures organized by the Alien Earth's team (and its predecessor EOS).*



# Financial Support, Startup Funds, and Living in Tucson

When you are admitted to our program, we make a commitment to support you for the years that it typically takes our students to complete the Ph.D. program. Support may come in the form of teaching assistantships, faculty grant-supported research assistantships, or fellowships (from NSF, NASA, or The University of Arizona). With summer employment, the total annual salary of over \$30,000 enables you to enjoy a comfortable lifestyle in Tucson where cost-of-living is moderate. Your tuition is waived or covered by the department.

When you are starting in our program, we provide you with a starting budget to cover the purchase of a computer and/or other expenses supporting your research. As students join specific research projects, the projects usually cover additional expenses, such as travel, a laptop, and membership fees.

Tucson and its environment constitute a thriving city of close to a million people, supporting a wide variety of events, attractions, activities, and restaurants. The University of Arizona itself provides a wide range of entertainment options, ranging from top-flight cultural activities to high-level college athletics. 300 days of sunshine per year, mountains with hiking trails, rock climbing, biking, and skiing, and the beautiful and biologically diverse Sonoran Desert encourages Tucsonans to pursue outdoor lifestyles.



*“The astronomy at Steward is world-class and getting outside around Tucson is pretty awesome too.”*

*Steph Sallum, Ph.D. 2017, and Faculty at UC Irvine*

Weather is hot and dry in May, June, and September, with July and August bringing spectacular monsoon thunderstorms. The weather is close to ideal during the remainder of the year. Many of our students also enjoy sports such as ultimate, basketball, softball, soccer, and other activities on a weekly basis. A sample of some of the local attractions include the Saguaro National Park, Sabino Canyon State Park, Catalina State Park, Mt. Lemmon, the Arizona-Sonora Desert Museum, Tohono Chul Park, and the Chuck Huckleberry Loop (offering 136 miles of paved pathways and bike lanes). Finally, Tucson is an affordable and convenient place to live. Some graduate students buy homes, others rent, but most find that their stipends make for a good standard of living.

**Further resources for living in Tucson:** [UA’s Off-campus Housing](#)



# How Can You Apply?

1. Read the letter from the Graduate Admission Chair in this brochure.
2. Carefully read the Application Requirements and Procedures in the next page (21).
3. Apply online through the University of Arizona Graduate Admissions webpage; please, apply only for FALL 2024 to the Astronomy and Astrophysics PHD program (identical to the astronomy program).

\*Applications received by December 4, 2023 will be given full consideration.

4. You will find information about our program in this brochure, and on the Steward Observatory website
5. We recommend that you also study our faculty and research groups' websites.

Have any further questions? Email Tiffany Deyoe ([tdeyoe1@arizona.edu](mailto:tdeyoe1@arizona.edu))

Good Luck!

## International Applicants

Our program strives to identify and attract the most promising and talented students who will flourish in our department from across the globe, regardless of their country of origin or the location of their undergraduate studies. Indeed, many of our current and past students have completed their undergraduate degrees outside the United States. A TOEFL examination is required for international students if you are not from an English-speaking country.

We recognize that different students may have different undergraduate educations. Once admitted, we work with all of our students to best complement their backgrounds, if necessary, or we can give you partial or full credit for courses that you have already completed, and which are deemed equivalent to the courses we require. Furthermore, we can offer start dates that are different from the beginning of the UA semester to accommodate your moving schedule and completion of another degree. No financial statements need to be sent to the Graduate College at this point in the application, nor are these statements impediments to attending graduate school here.

### Questions?

With questions on application procedure and material email **Tiffany Deyoe ([tdeyoe1@arizona.edu](mailto:tdeyoe1@arizona.edu))**.

With questions on the graduate program email **Andrew Youdin, Chair of the Graduate Admission Committee ([youdin@arizona.edu](mailto:youdin@arizona.edu))**.





# Application Requirements and Procedures

**Deadline:** Dec. 4, 2023 for all applicants

Instructions can be found on the on-line Graduate College Admission application. Once on UA's GradApp apply for the "Astronomy and Astrophysics PHD" program (this is the same as the Astronomy PHD program). Admission for Graduate Study in the Department of Astronomy is for the Ph.D. program only. We do not support a Master's Degree program, and requirements are geared toward Ph.D. studies. Undergraduate training in Astronomy is not a necessity for students to pursue an Astronomy Ph.D. at The University of Arizona. A thorough background in physics, however, is essential. Applications are judged on the basis of undergraduate curriculum and performance, research experience (if any), 3 letters of recommendation from faculty or supervisors familiar that lists your capabilities, and a statement of purpose. For a foreign student from a non-English speaking country, you will additionally need to take the TOEFL examination by the beginning of December. (TOEFL scores must be valid for 2 years prior to the enrollment term you are applying for.)

**Statement of Purpose:** The statement of purpose, of 1-2 pages, should briefly describe why you want to pursue the Ph.D. in Astronomy, your past research experiences (if any), what specifically you contributed to and gained from those research experiences, your current scientific interests, your future goals, why you have chosen the University of Arizona. If there is an aspect of your academic record that is unusual, please briefly discuss it.

**GRE Exams:** *For admission to the 2024 academic year, the Department of Astronomy neither requires nor accepts the General GRE or the Physics GRE score.*

## **Decisions:**

Admissions decisions will be announced on or before April 1. By agreement among astronomy graduate departments, successful applicants must announce their decisions by April 15.

## **Addresses:**

Steward Observatory Graduate  
Admissions 933 North Cherry Avenue,  
N204  
Tucson, AZ 85721-0065  
Academic Office

The University of Arizona Graduate  
College/ Admissions P.O. Box 210066  
Administration Building, Room  
322 Tucson, AZ 85721-0066



Department of Astronomy & Steward  
Observatory

Graduate Admissions  
933 North Cherry Avenue, N204 Tucson,  
AZ 85721-0065

