Honest advice for the astronomy grad school application process

Preface: This is a compilation of my thoughts on the astronomy/astrophysics grad school admissions process. I have a unique perspective on the process, having been rejected by every school in my first application season, then being successful my second time applying. I think that all of my advice is applicable to anyone applying to astronomy grad school and I hope you find this useful. Although I am not an expert, I feel that I know the process very well and if you have any questions about anything I didn't cover, feel free to reach out to me at mileshcurrie@gmail.com. I'm happy to help in any way I can.

I. **Things you should know before applying:**
   A. Astronomy is one of the most competitive fields of study for grad school
      1. There are roughly 40 PhD granting institutions in pure astronomy
      2. These programs have 5-10 slots available each year
      3. 5-15% acceptance rates are the norm
      4. There are plenty more physics PhD programs with an astronomy track, but this document will mostly focus on applying to astronomy programs
   B. You will not get into every program you apply to. The competition is fierce.
   C. You may not get in your first time applying
      1. Don't worry! This is not the end of the world! Read on!
   D. Networking is an incredibly important tool. Meet all the people you can and make personal connections. Careers are built off networking.

II. **Choosing Schools to apply to:**
   A. Half of the programs you apply to should be physics/astrophysics joint departments
      1. These have more slots available per year
      2. Acceptance rates are higher
      3. I didn't do this either of the times I applied and it was a huge gamble
         a) Don't be like me, I made a mistake (twice). Apply to these programs.
   B. There is no such thing as a safety school
      1. Focus on research match, not the brand name of the school
      2. If the institution grants PhDs, it's already great
      3. I was rejected from ALL of my "safety" schools but got into several of my top choices
   C. Apply to places you think you'll be happy
      1. If the beach and sunny weather matters to you, apply to programs in CA, HI, FL, etc.
      2. If you don't think you can live in a big city, don't apply to those programs

3. Work/life balance is a major part of being successful in grad school. If you're happy, you work better.
4. For each school you're considering, ask yourself this question: If I get rejected from everywhere but this school, would I be excited about going there? If the answer is no, don't apply to that school.

D. Look for diversity in research
    1. Sure, you want to study exoplanets now, but what about in two years when you're sick of it?
    2. I know several people who thought they knew exactly what they wanted to do before grad school, but ended up switching in the first couple of years.

E. Choosing a subfield
    1. You should have an idea of what subfield you want to study, but you are by no means locked in to that field and can change your mind later.
    2. Some schools are better at certain subfields than others
    3. Some warnings:
        a) Everybody and their dog wants to do exoplanets. It's the most competitive subfield.
        b) Also very competitive: gravitational waves, cosmology
        c) Theory is more competitive than observation. Funding is more limited for theoretical work.

F. Choosing an advisor
    1. This is tricky. It's hard to judge what someone is like without meeting them
    2. As you look at schools, you should email professors whose research interests you to introduce yourself and ask if they are taking on any students in the next few years
        a) Most professors will reply, but whether it's a "thanks for your interest, you should apply" response or a more engaging response is up to the individual professor
            (1) The more engaging professors played a big part in where I enrolled in the end
        b) Some will not reply at all
            (1) Do you really want to work with someone who doesn't have time to send even a simple response? Do you think they will have time for you as their student?

G. In case you missed it the first time:
    1. Don't worry about the brand name of the school
    2. It's true that in general, the top ten schools will have the most interesting research, the most famous faculty, and the best resources, but that is not the rule. Smaller departments have produced many successful (and famous) researchers and are sometimes better at certain subfields than the top ten.

III. Application

A. There is no sure-fire formula for a successful application, but here's what I think matters based on my experiences:

1. **General GRE**
    a) Don't bomb it and you'll be okay
    b) Shoot for >70th percentile, it's not worth it to retake it to get higher than that
2. **Physics GRE**
    a) Some places care about this more than others
    b) There is a big movement in astronomy to get rid of it (see https://arxiv.org/abs/1512.03709), so by the time you apply, more schools may not consider it
    c) You probably don't want to be in a department that puts too much consideration into this anyway
        (1) It makes no sense to analyze a single data point (you wouldn't classify a star cluster based on an observation of one star, would you?) *credit: astrobites
        (2) This is usually, but not always, an indicator of aging faculty, a non-progressive department, or a toxic work environment
3. **GPA**
    a) This matters, especially your junior/sophomore GPA
    b) Most people applying have above a 3.3
    c) Competitive applications have 3.6+
    d) My physics/astro GPA was around a 3.6, which was on the lower end of people who were accepted at the places I was visiting
4. **Research Experience**
    a) One of the most important parts
    b) If you're not already involved in research, get involved now. The earlier the better
    c) The most common way to find research experience is asking professors whose research interests you if they have time to take you on for a research project
        (1) These usually start unpaid, but there may be opportunities to be paid later on, depending on you advisor's financial situation
    d) You can apply for summer internships/REUs
        (1) These are paid experiences at different locations in the US
        (2) My REU was one of the best summers of my life, I highly recommend them!

(3) Be warned that they are very competitive, but the applications are free. You should complete as many as you can.
(4) http://www.astrobetter.com/wiki/tiki-index.php?page=Summer+Internships

5. **Statement of Purpose**
    a) Another very important part of the application
    b) In this, concisely outline your experiences and why you would be a good fit at X University.
    c) This should be tailored to every program you apply for.
    d) Think of this as a sort of sales pitch. You're selling your skills and potential
    e) Leave out anything irrelevant to astronomy/research
    f) DO NOT mention anything before undergrad unless it's a relevant high school internship, but even then keep it brief
    g) The admissions committee does not care that you got interested in physics and astronomy by looking up at the stars when you were young or watching a slinky on the stairs or meeting Bill Nye when you were 5. Your interest in this field is apparent by your writing this application in the first place. Leave these cliches out.
    h) Extracurricular activities:
        (1) Worth mentioning if it was something significant like volunteering or outreach
        (2) If it is not relevant to astronomy/physics, keep it brief
    i) The SOP is to show that you know how to write, an important and necessary part of being a researcher
6. **Outreach/volunteering**
    a) Very important
    b) This is an area where you can be creative and really set yourself apart from the rest of the applications
    c) Most grad schools like to see that you're dedicated to not just pursuing research, but sharing your research with the world (public interest = funding)
    d) Some applications even have a separate essay where you can talk about these achievements
    e) Look for opportunities to volunteer with local science museums, observatories, astronomy clubs, etc
    f) It does not have to be astronomy related, but it helps
7. **Letters of recommendation**
    a) Choosing who you want to write your letters of recommendation is tricky business. People told me many different strategies for this, so here's what worked for me:

(1) Choose the advisor you're closest with or have known the longest. For me, it was someone I worked with for over three years.
(2) Choose someone who taught you in an astronomy/physics class. This could be your favorite professor, a professor whose class you did really well in, or a professor who knows you well from taking multiple classes with them
(3) Your third letter could be either another (2) or a different advisor you did research with during a summer for instance
(4) Fourth letters are sometimes optional and some people told me not to submit one, but I did anyway. I don't think it hurt. If you know for a fact that your fourth letter will be just as strong as your other three, I think it's okay. This letter can be another research advisor or professor. My fourth letters were from a research experience I had outside of astronomy, and I think it helped set me apart!

b) Only get letters from professors or research advisors. That's it.
c) Email your letter writers a couple months in advance asking if they would be willing to write you a ***strong*** letter
d) Send periodic reminders as the deadlines approach. Most departments are lenient with professors submitting their letters a little late, but it's best to just have them submitted by the deadline.

B. FSU-specific notes

1. FSU astrophysics is a small and a lesser known department in this field, however I don't think this is necessarily a bad thing
2. The accessibility of undergraduate research in astronomy at FSU is really phenomenal
    a) Because it is a small department, I felt that I got a lot of one-on-one time with my research advisor. This is rare in big departments
3. The bad part of a small department: In certain schools (I won't name names), it is uncommon to see acceptances from lesser known departments like FSU. That being said, I think it is worth it to apply anywhere you want to go and you shouldn't worry too much about this. Just focus on making your application exceptional!

IV. Results

A. If you got rejected everywhere, don't panic!
    1. I have a lot to say about this, so I made it its own section. Go on to section V.
B. If you got accepted to one or more, congrats! You're going to grad school!
    1. make sure you visit all of the schools you got into, even the one lowest on your list. You may be surprised.
    2. Ask lots of questions when you visit. Sample questions:

a) For current grad students (they will be the most honest with you):
    (1) Are you happy?
    (2) Is the stipend enough to live comfortably on?
    (3) Why did you choose to go to this school?
    (4) Was there anything surprising about attending this school?
    (5) Do you like living in this city?
    (6) What do you do for fun? Social life?
    (7) How did you choose your advisor? What is their advising style?
    (8) What kind of resources do you have as a student? computing, travel, observatory support, publications, attending conferences
    (9) How long does it take to graduate?
    (10) Who are the best advisors? The worst?
    (11) What is diversity like at this school?
b) For faculty/staff:
    (1) What is the process for choosing a thesis topic?
    (2) Do you collaborate with any other professors?
    (3) What is your advising style?
    (4) How often do you publish?
    (5) Where do you see your research going in the next five years?
    (6) Where do PhD grads go? Fellowships? Postdocs? Leave academia?
    (7) How many papers are grad students expected to author? How many do they actually author?
    (8) What is the graduation timescale?
    (9) What is the process like from entering to getting a PhD?
    (10) What kind of resources do students have? computing, travel, observatory support, publications, attending conferences
    (11) What resources are available for students for: finding housing, resolving various kinds of difficulties (roommates, office mates, peers, professors, personal), adjusting to grad school
    (12) What is the health insurance like?

V. I was rejected everywhere. What to I do?

A. Don't worry. This happened to me the first year I applied. I had a great application and was confident I would get into grad school, but sometimes things just don't work out.
B. Here are some things I think I did wrong my first time applying:

1. I was too narrow in my statement of purpose. I thought I knew exactly which niche, tiny subfield I wanted to work on and didn't express that I was open to anything else.
2. I didn't get enough opinions on my statement of purpose. I only let a handful of people read it because I was scared for people to read my writing. YOU HAVE TO GET OVER THIS. Everybody writes terrible drafts. You should be sending your SOP to everyone you know and trust (professors, colleagues, advisors, friends, students, etc.) to get all of the input and suggestions you can. Most advice will be good.
3. I had a few regrettable grades on my transcript, and it may have held me back a little. But at this point there's nothing you can do about those grades. The best thing to do is deemphasize them as much as you can by your other accomplishments
4. My physics GRE score was not so great (40th percentile), and this mattered to some of the grad schools, but not all of them. The question of whether you should take it again is a tricky one. If you have the time to sit down and study for MONTHS, and I'm taking a few hours a day, then you should retake it. Otherwise, don't worry about it. Don't apply for programs that require it. Fun fact: I retook it and did worse my second time.

C. Mental/emotional aspect:
    1. It hurts, I know. My "imposter syndrome" was at an all time high in the months following my rejections. But the thing to remember is that you are about to graduate (or already did graduate) with a degree in physics/astrophysics, one of the hardest majors at any university. You made it, and that is something to celebrate. If you need to talk more about this, please feel free to email me. I made it through and you can too. But again, I am no expert, and there is always professional counseling available through the university.
    2. Something that helped me through was just focusing on making my application better for the next application season. I used the rejections as motivation to be better next year and because of this I was more proactive in looking for new opportunities in research, volunteering, etc.
    3. If you really want to go to grad school, rejections shouldn't stop you. (Be warned: academics have careers built around rejection). If you have the willpower and funds, try again next year.
    4. Universities are forced to reject many qualified applicants each year due to funding issues. Getting a rejection does not mean you're not qualified.
    5. Remember you are not alone! This happens to more people than you realize. In fact, nobody from my REU got into grad school the first year I applied, even the ones who I thought would surely get in.
D. At this point you have two options:
    1. Option 1: get a temporary job while you prepare to apply again

a) Finding a temporary job in astronomy/physics research is hard. There are not that many positions available. You should check around at places like the AAS job register (jobregister.aas.org) or other physics jobs sites and definitely apply to these positions if there are any, but your best bet for doing research for a year is reaching out to your network. I was lucky enough that someone in my network was at a very well known astronomy research institute and had some extra money lying around, so they agreed to hire me for a year. As far as I know, this is not very typical, but it can't hurt to ask old or current advisors if they can hire you or if they know anyone who can hire you. Beyond research, I know plenty of people who have gotten jobs or year-long internships as programmers, engineers, working at their local newspaper, even waiting tables! However, those who got non-technical jobs also continued part-time unpaid research at their home institution. Everyone I know who didn't give up in their pursuit eventually got accepted. It takes dedication, perseverance, and a little bit of luck. You'll get there.

2. Option 2: leave academia/research and get a big kid job
    a) This is totally respectable, and even preferable if you want to have any hope of making real money in the next decade or two. The great thing about a physics degree is how versatile it is. You can be an engineer, programmer, data scientist, the possibilities are nearly endless. Jobs are easy enough to come by if you aren't picky. Just submit applications to different jobs and see where it takes you! I actually had a job offer at an engineering firm right out of college, but I chose option 1 instead. The good thing with this option is that you can change your mind later down the road and still go to grad school. This is more rare, but people do it. The experience would probably look really good, as long as it is somewhat relevant to astronomy/the skills you need for astronomy. Note: I would have chosen this option had I not been successful my second time applying.

VI. Handy Resources

A. Schools offering pure astronomy/astrophysics PhDs as of Fall 2018, in no particular order

University of Arizona
Arizona State University

Boston University
University of California, Berkeley
University of California, Los Angeles
University of California, Santa Cruz
Case Western Reserve University
University of Chicago
University of Colorado at Boulder
Columbia University
Cornell University
University of Delaware
University of Florida
Harvard University
University of Hawaii
University of Illinois Urbana-Champaign
Indiana University
Iowa State University
Johns Hopkins University
Kansas State University
University of Maryland
University of Massachusetts, Amherst
University of Michigan, Ann Arbor
Michigan State University
University of Minnesota
New Mexico Institute of Mining and Tech
New Mexico State University
Northern Arizona University
Northwestern University
Ohio State University
University of Oklahoma

Penn State University
University of Pennsylvania
Princeton University
Rice University
Rochester Institute of Technology
Rutgers, The State University of New Jersey
University of Texas at Austin
University of Virginia
Virginia Tech
University of Washington
University of Wisconsin at Madison
Yale University

B. Physics GRE requirements by school: https://docs.google.com/spreadsheets/d/19UhYToXOPZkZ3CM469ru3Uwk4584CmzZyAVVwQJJcyc/edit#gid=0
C. General tips and tricks for astronomers: http://www.astrobetter.com/wiki/Wiki+Home
D. Interesting stuff targeted to undergrads: astrobites.com
E. Papers: arxiv.org, http://adsabs.harvard.edu/abstract_service.html
F. Relevant blogs:
    1. Warning, these can become very toxic to your mental health in the application process, but can also be powerful resources. Use at your own discretion.
    2. thegradcafe.com If you click “results search” and then type astro* in the search bar, it will show you historical acceptances and rejections from all the programs. People will post on there as they get accepted or rejected. You can see how this can be toxic.
    3. physicsgre.com If you click “prospective physics grad student topics”, there are answers to many important questions on the application process, as well as a forum where people post their profiles and what schools they are applying to. Don’t get scared away, though, most of the people who post on there are in the top 5% of applications and therefore get in everywhere. There’s still plenty of room for us average joes/janes :)
G. One of my successful statements of purpose, some information redacted:

In the summer of 2017, I found myself in the middle of a forest in southern Georgia wearing a full-helmet respirator and a thick fire-proof suit. Mere minutes before, a prescribed forest fire raged exactly where I was standing and my instrument to measure the heat flux of the passing flame front was heavily charred, barely distinguishable from the surrounding burnt forest. Forest fire research is very similar to research in astronomy, which is why I had been offered the unique opportunity to conduct research at <???>, and why I was sweating in thirty pounds of clothing in the middle of a hot Georgia summer. Working with Dr. <???>, who leads a group that uses fluid dynamics to model the spread of forest fires, my objective was to image prescribed burns from above and analyze the data to investigate the effect of terrain and wind vectors on fire spread. This resulted in a recent paper submission constraining a simple probability distribution for one patch of land igniting due to any number of adjacent burning patches. I developed an analysis pipeline to look for temporal changes in the time-series data cubes, exactly as I had previously looked for changes in flux of a host star over time to detect exoplanet candidates.

The previous summer, I was in the REU program at <???> working with Dr. <???> and Dr. <???> on Kepler and K2 data where I developed a novel approach to finding exoplanet signals buried in noisy K2 light curves. K2 is the successor to the Kepler mission and operates using only two out of the original four reaction wheels. Thus, the K2 data are much noisier due to the constant thruster corrections for the motion of the telescope. Using principal component analysis (PCA) for each pixel's time-series as a noise reduction algorithm, we hypothesized that the most influential principal components correspond to the motion of the telescope. After the correction for the first few principal components, the noise in the light curves was found to be reduced by up to a factor of five. My detrending algorithm was later implemented in NASA's Discovery And Vetting of Exoplanets (DAVE) pipeline.

I have been doing research since my freshman year at Florida State University in high energy physics, aerospace engineering, and supernova cosmology. These early experiences gave me the basic tools–independent problem solving, Python programming, and statistical analysis–for conducting research and led to being hired at <???> as a post-baccalaureate researcher in the supernova cosmology group of Dr. <???>, Dr. <???>, and Dr. <???>.

In my current project at <???>, I am addressing the fundamental issue of removing instrumental signatures in type Ia supernova (SNe Ia) data obtained with multiple telescopes, in an effort to reduce systematic uncertainty in the cosmology fits of SNe Ia. Systematics are the dominant source of uncertainty in modern SNe Ia cosmology and reducing their effect is critical for understanding dark energy. Many important surveys lack well characterized system throughputs and I use Bayesian statistical analyses to create a global hierarchical model of tertiary stars in the SNe Ia fields of these surveys, which ultimately reduces the systematic uncertainty associated with the photometry and leads to better cosmological constraints. I have begun work on creating an automated transient finder using a convolutional neural network. Preliminary studies show that using a simple neural network is already competitive with state of

the art machine learning techniques like random forest transient finders and a more complex system will exceed today's models. The network will be trained and applied to MAST (Mikulski Archive for Space Telescopes) archival data to compile a list of transient detections. In the future, the pipeline will be able to search any archival database for transients.

Because of my interest in the detection, characterization, and habitability of exoplanets, the University of <???> is the ideal place for me to explore and build my career. The research of Dr. <???> and Dr. <???> appeal to both my interests and experience.

Many of the research skills I have learned align well with the skills necessary to be a member of Dr. <???>'s research group. His recent use of a Markov Chain Monte Carlo sampler to constrain parameters describing surface densities for M dwarf exoplanet systems is an application of the same style of my current analysis method. Performing this analysis on future surveys, I want to help correlate this information with Dr. <???>'s work on exoplanet mass functions by using Gaussian process or Bayesian modeling, which will reveal more about the formation and evolution of planetary systems. Furthermore, Dr. <???>'s and his group's involvement in the JWST mission will make for even more exciting projects in the near future. The guaranteed observing time through their involvement with NIRCam and NIRIS will provide opportunities for direct imaging surveys and high signal-to-noise spectroscopic measurements of exoplanet atmospheres, two exciting areas where I can apply my expertise in building and maintaining analysis pipelines.

Using a more theoretical approach, Dr. <???>'s research appeals to my interest in characterizing exoplanetary atmospheres with computational methods. Contributing to her three-dimensional atmospheric modeling software, I want to help add new physics to account for parameters that will help us in our search for Earth analogues. Although most of the exoplanets currently being characterized are hot jupiters, I am excited by the upcoming surveys and new instruments that will help us characterize smaller, rocky planets. Her development of observational methods is another area where my experience will be useful, especially with the imminent JWST mission and its capabilities for exoplanet science.

The University of <???> is an attractive place to pursue a PhD because of the exoplanet research carried out by its astronomy department faculty. Its access to state of the art research facilities opens up opportunities to be connected with the world's astronomy community. The University of <???> has all the resources that will enable me to explore and build a research career. Given my interests and experience, I believe I will fit in and succeed at the University of <???>'s Department of Astronomy.