I intend to complete a Ph.D in astronomy research in the field of extrasolar planet and brown dwarf detection, characterization, and formation. Following completion of my Ph.D, I intend to continue to work as an astronomy researcher, ideally at an observatory or research institution such as NASA. University faculty is also a position I will consider. I intend to pursue a career path that will allow me to continue to do astronomy research.

My path to astronomy is non-traditional and non-linear, but **it is precisely because of this winding path I now know for certain that a career as a researcher in exoplanetary astronomy is the ideal path for my future.** Every choice I have made as a student, every opportunity I have pursued, has been with this goal in mind.

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While a second-time student at the University of Texas at Austin, I worked in the Hobby-Eberly Telescope Dark Energy Experiment instrumentation laboratory, assembling the units of the VIRUS instrument for UT's ambitious research project to measure the expansion rate of the universe. During my first summer I participated in a Research Experience for Undergraduates (REU) at Northern Arizona University (NAU) in the field of planetary science, determining if it is possible for the lakes on Titan to freeze during seasonal variations. I spent this past summer with the Berkeley SETI Research Center at the University of California Berkeley, on the Breakthrough Listen (BL) project to search for technosignatures in primarily radio wavelengths. Working with Howard Isaacson, I developed the "1 Million Star" target list for BL's upcoming observing campaign with the MeerKAT telescope in South Africa, which will be the largest Search for Extraterrestrial Intelligence (SETI) search in history.

But the most impactful research experience was my work Dr. Adam Kraus on **an orbit study of the wide planetary mass companion GSC 6214-210 b.** Dr. Kraus' program has been monitoring several of these type of companions for many years with images from the Keck Telescope, enough time to measure orbital motion. Planetary mass companions (PMCs) are large companions ($\sim$13 M_{jup}) on wide orbits ($\geq$100 AU) from their hosts that have been detected in imaging of young systems. I find PMCs exceedingly interesting because they occupy a parameter space that is difficult to explain with current brown dwarf and planetary formation mechanisms. In my work on the PMC system GSC 6214-210, I measured the astrometric relative motion of GSC 6214-210 b, fit Keplerian orbital parameters to the motion, and studied the fit for clues which could point to formation mechanism, building my own statistical algorithms. I concluded that the $\sim$14.5 M_{jup} companion was unlikely to have formed at a close radius, where the disk is thicker, and then been scattered out to its current wide orbit through a dynamical scattering interaction. **My first author paper has been submitted for publication to the Astrophysical Journal.** I also have worked with **Sarah Blunt** on the Orbitize open-source python package for astrometric orbit fitting.

Study of these systems is hampered by the exceedingly small population that is known today. **?** determined the occurrence rate of planets (5-13 M_{jup}) at separations observable in imagining (30-300 AU) to be only $0.6^{+0.7}_{-0.5}$%. With such a low occurrence rate, direct imagining survey strategies must be optimized to select targets that maximize the likelihood of finding a giant planet or brown dwarf companion.

This led me to propose a project for the NSF Graduate Research Fellowship Program to use multi-epoch astrometry to optimize a target list to detect new directly imaged companions. As recent studies have shown (**?**, **?**, **?**), the large time baseline between *Hipparcos* and *Gaia* astrometry allows for detection of long period accelerations due to the presence of a companion of a wide orbit. Thus, by comparing the two epochs, I proposed to look for stars experiencing acceleration, and develop a target list optimized to identify substellar companions. I then proposed to follow up the target list of $\sim$50 targets, which is the upper end of the number of targets that could reasonably be surveyed during my PhD tenure, with a high-contrast imaging survey to detect the companions.

Harvard University, with its wealth of exoplanetary knowledge and access to observing resources, is an ideal institution to pursue a graduate degree in exoplanet studies. I have very much enjoyed my work with high-contrast imaging, but am open to other fields within the exoplanet community as well.

However the main reason I would like to study at Harvard is the expertise of your exoplanet community. Sean Andrews comes highly recommended to me as a mentor, and I find the work of his research group very interesting. My work on PMCs has shown me the wealth of scientific questions to be answered in star and planet formation, and his work on structure in protoplanetary disk is very exciting. I am also interested in **David Charbonneau**'s MEarth project and work on exoplanetary atmospheres. The exoplanet community at Harvard, from what I have learned about your program, sounds like just the kind of learning and research atmosphere I am looking for in a Ph.D program.

I am excited about the project I have proposed for NSF funding, however **I am open to other exciting research ideas as well.** I am committed to pursuing exoplanet research, and I am very flexible and open to adjusting the course of my Ph.D work. I do hope to be able to pursue my Ph.D at Harvard for all of the reasons I have listed above, in addition to the appeal of living in Boston. Thank you for considering my application to your prestigious research institution. My research, cv, and bio can also be found at www.loganpearcescience.com.

Statement of Purpose

I intend to complete a Ph.D in astronomy research in the field of extrasolar planet and brown dwarf high-contrast imaging and formation. Following completion of my Ph.D, I intend to continue to work as an astronomy researcher, ideally at an observatory or research institution such as NASA. University faculty is also a position I will consider. I intend to pursue a career path that will allow me to continue to do astronomy research.

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I began a **second bachelor's degree in astronomy and physics** at the University of Texas at Austin in 2015. Because I entered with the goal of becoming an astronomy researcher, I immediately set about the process of obtaining as many skills and diverse set of experiences as possible. I began with a job in the Hobby-Eberly Telescope Dark Energy Experiment instrumentation laboratory, assembling the units of the VIRUS instrument for UT's ambitious research project to measure the expansion rate of the universe. During my first summer I participated in a Research Experience for Undergraduates (REU) at Northern Arizona University (NAU) in the field of planetary science.

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Study of these systems is hampered by the exceedingly small population that is known today. Bowler (2016) determined the occurrence rate of planets (5-13 M_{jup}) at separations observable in imagining (30-300 AU) to be only $0.6^{+0.7}_{-0.5}\%$. But in addition to studying population statistics for these systems, direct imaging of giant planet companions is a valuable tool for study of extrasolar planets because of the ability to study the planet directly, rather than through its influence on the host star. These valuable systems are being used to inform planetary evolutionary models, distinguish between planet formation pathways, and determine the dependence of atmospheric clouds on mass and age. However, more giant planets are needed to develop meaningful statistical characterization of this population group and their host stars, and understand them as outcome of the planet formation process. With such a low occurrence rate, direct imagining survey strategies must be optimized to select targets that maximize the likelihood of finding a giant planet or brown dwarf companion.

This led me to propose a project for the NSF Graduate Research Fellowship Program to use multi-epoch astrometry to optimize a target list to detect new directly imaged companions. As recent studies have shown (Snellen & Brown (2018), Bowler et al. (2018), Calissendorff & Janson (2018)), the large time baseline between *Hipparcos* and *Gaia* astrometry allows for detection of long period accelerations due to the presence of a companion of a wide orbit. Thus, by comparing the two epochs, I proposed to look for stars experiencing acceleration, and develop a target list optimized to identify companions based on the magnitude of the acceleration (to be consistent with planet masses), stellar multiplicity (to rule out binary systems), distance (closer objects will have larger angular separations), and age of host star (younger planets will be brighter). I then proposed to follow up the target list of ∼50 targets,which is the upper end of the number of targets that could reasonably be surveyed during my PhD tenure, with a high-contrast imaging survey to detect the companions.

University of Hawaii Manoa Institute for Astronomy is an ideal institution to carry out this study. Your institution comes highly recommended to me as a hub for exoplanet research. The access to observing resources at Hawaii is unparalleled, and also makes it a ideal place for my research. My undergraduate work was conducted using NIRC2 data from Keck Telescope, and I even was able to travel to Keck with Dr. Kraus in 2017 to collect more data for my project, and fell in love with observing there and with Hawaii. I would ideally like to continue to pursue high contrast imaging with Keck, or other Hawaiian telescope resources.

However the main reason I would like to study at IfA is the expertise of your exoplanet community. Many current astronomy faculty at UT Austin have come through your institution, including my undergraduate research advisor and several co-authors on my paper. I am particularly interested in the exoplanet characterization and adaptive optics work of Daniel Huber's research group. He comes highly recommended to me as a researcher and a mentor, and I feel that my research experience and interests would be an asset to his group, and his expertise, resources, and mentorship would be vital to my science and growth as an astronomer. Jennifer Van Sedars also conducts research I am very interested in, as does Michael Liu. The exoplanet community at IfA, from what I have learned about your program, sounds like just the kind of learning and research atmosphere I am looking for in a Ph.D program.

I am excited about the project I have proposed for NSF funding, and how well it would be served at IfA, however **I am open to other exciting research ideas as well.** I am committed to pursuing exoplanet research, and I very much enjoyed the high contrast imaging work I have done previously, and would like to continue in it. But I know that plans have a high likelihood of changing, and I am very flexible and open to adjusting the course of my Ph.D work. I do hope to be able to pursue my Ph.D at IfA for all of the reasons I have listed above, in addition to the appeal of living in Hawaii. Thank you for considering my application to your prestigious research institution. My research, cv, and bio can also be found at www.loganpearcescience.com.

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I plan to pursue a doctoral degree in astronomy with the goal of conducting original research in extra-solar planet discovery and characterization. My path to astronomy is non-traditional and non-linear, but it is precisely because of this winding path I now know for certain that a career as a **researcher in exoplanetary astronomy** is the ideal path for my future. Every choice I have made as a student, every opportunity I have pursued, has been with this goal in mind.

Although I have always had an interest in astronomy, I obtained a bachelor's degree in chemistry from Purdue University as a traditional college student in 2003, and earned a commission as an **officer in the US Navy** upon completion. I sought appointment in the Navy's nuclear power program because of the degree of academic challenge it afforded. I was not disappointed. The academic rigor in the schooling and subsequent work in the fleet is unparalleled by anything in the civilian world, in my experience. I served in many roles during my 5 years in the Navy, but the most impactful for me was as a nuclear power plant operator and maintenance division supervisor aboard the aircraft carrier USS John C. Stennis (CVN-74) for over 2 years in both war-time and maintenance conditions. In that capacity, I was continually challenged as a learner, a decision-maker under pressure, and a leader of personnel. The skills and experience I gained from that short intense time are too numerous to recount in detail here, but are an essential part of who I am and a factor in all my successes going forward.

Following separation from the Navy in 2008, I obtained a teaching certification and served as a **middle school science teacher** in Texas for 6 years. I taught in an advanced magnet program, and I focused my classes on teaching physics and engineering. I believe strongly in the power of engineering projects to drive student intellectual development, and so in 2014 I completed a Master's degree in engineering education in which I conducted original research on the effects of a well-designed engineering lesson on student development, while working as an in-service teacher. I also designed a popular elective course at my school in which students designed a crewed mission to Mars. The students' excitement in studying space rekindled my own love of astronomy, and I decided to leave teaching to pursue a career as an astronomer. It had been so long since I had studied math and physics that I quickly realized I needed to re-learn the basics to be successful as a researcher, and I am glad I did. I found the truth of the saying ”I didn't know what I didn't know”.

As recounted in my statement of purpose, I pursued several research experiences, both at UT Austin and other institutions. I have attended multiple conferences and presented my research, and become an active member of the astronomy community. I've found a lot of purpose and fulfillment in making meaningful contributions to the progress of astronomy, which is the main reason I decided to pursue this opportunity. And getting to make a living studying how planets form is just so darn cool.

While a second-time student, I got involved in outreach as quickly as possible. I am part of the team that puts on the monthly Astronomy on Tap (AoT) show in Austin, the most highly-attended AoT show! AoT is an organization that hosts regular astronomy outreach talks for the public at a local pub. I make videos for the show, graphics, and help with merchandise. I love Astronomy on Tap and intend to get involved in the local show wherever I end up as a graduate student.

I also derive a lot of satisfaction and purpose from helping my peers take full advantage of the opportunities provided by being a UT Austin astronomy student. I served for three years as one of the Astronomy Department Undergraduate Representative, in which I facilitated communication between the department and the undergraduate population. We hosted several UG town hall events to provide feedback to the department, application workshops, a ”welcome to the astronomy department” event for new students, and wrote a white paper for the departmental external review in 2017. Additionally, I severed as a Student Veteran Services Peer Mentor for one school year, in which I helped fellow veterans transition to student life and find community. I look forward to continuing to be a cheerleader for my peers in graduate school.

Additionally, I am strongly motivated to leverage my unique position as a former teacher in outreach. It can be difficult for teachers, with many other professional demands, to develop an intuitive sense of how the scientific community generates and evaluates new knowledge. Yet teaching this in schools is vital, as teachers can be front-line actors in improving the nation's science literacy. Giving secondary science teachers direct experience in carrying out a science project, then, represents an invaluable opportunity for the scientific community to help shape the scientific literacy of the nation. I became aware of the NSF's Research Experiences for Teachers (RET) after I had already left the teaching profession, but immediately recognized its potential power. I had attended numerous teacher workshops, which were excellent, but I would have leaped on the opportunity to actually do real science. I found that there were not many RET programs available, and those were mostly engineering and computer science focused. **I want to begin an astronomy RET program at my graduate institution.** I believe Michigan, with its reputation for excellent astronomy research and dearth of opportunities in exoplanet research, is the perfect location for an astronomy RET program.

Because of my unique background, I can readily see the power and need for this type of outreach to the public. The potential of a few teachers coming to my school for the summer can have a compounding impact on the community and the nation. Get the teachers, you get the students, who get the parents, who get the community. I very much want to see this program expanded to many science disciplines, and plan to pursue outreach to teachers as a graduate student. I want teachers to have the same sort of life-changing research experiences I have been privileged to have.

The University of Michigan is an ideal location for me to pursue my interests. The astronomy department has an excellent reputation for research and community, and has been highly recommended to me by many in the exoplanet field. The research at U of M is the main draw for me (discussed in detail in my research statement), but what I know of the astronomy community there is also a contributing factor. I have been in challenging mental and physical environments before, and I am looking to join a supportive community that values work/life balance and mentorship of early career scientists.

It took me a while to find purpose in my career, but I have no doubt I have found it. **Astronomy is my path**, with a career as a research scientist, ideally at a national laboratory or observatory. Graduate school will prepare me for research as a professional astronomer, refine my skills at conducting and communicating research, and to continue encouraging peers and mentoring younger students. I believe I have a lot to offer Michigan Astronomy, and that the education I would receive there would be top notch, and set me up for success in my future astronomy career.

I intend to complete a Ph.D in astronomy research in the field of extrasolar planet and brown dwarf detection, characterization, and formation. Following completion of my Ph.D, I intend to continue to work as an astronomy researcher, ideally at an observatory or research institution such as NASA. University faculty is also a position I will consider. I intend to pursue a career path that will allow me to continue to do astronomy research.

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As detailed in my personal statement, I returned to university to pursue a career in astronomy following a career in the US Navy and another as a middle school science teacher. While a second-time student at the University of Texas at Austin, I worked in the Hobby-Eberly Telescope Dark Energy Experiment instrumentation laboratory, assembling the units of the VIRUS instrument for UT's ambitious research project to measure the expansion rate of the universe. During my first summer I participated in a Research Experience for Undergraduates (REU) at Northern Arizona University (NAU) in the field of planetary science, determining if it is possible for the lakes on Titan to freeze during seasonal variations. I spent this past summer with the Berkeley SETI Research Center at the University of California Berkeley, on the Breakthrough Listen (BL) project to search for technosignatures in primarily radio wavelengths. Working with Howard Isaacson, I developed the "1 Million Star" target list for BL's upcoming observing campaign with the MeerKAT telescope in South Africa, which will be the largest Search for Extraterrestrial Intelligence (SETI) search in history.

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The University of Michigan, with its wealth of exoplanetary knowledge and access to observing resources, is an ideal institution to pursue a graduate degree in exoplanet studies. I have very much enjoyed my work with high-contrast imaging. It is the most satisfying way to study planets and planet formation to me, to directly observe their photons, and is the most powerful tool for understanding planet formation. Michigan Astronomy has many experts and exciting programs in direct imaging that I am very interested in, and the promise exciting returns in imaging planets. **John Monnier's** work with adaptive optics and the fringe tracker on CHARA array is on the cutting edge of imaging planets and planet-forming disks in infrared. I recently read his paper from this summer about the proposed Planet Formation Imager, which is so exciting and the next step in evolution of studying planet formation, to see it actually occurring in the infrared. I am also very interested in the work of **Ted Bergin's** research group on observing the formation of planets and protoplanetary disks in radio wavelengths.

I love the promise of high-contrast imaging for study of planet formation, but I am open to other fields within the exoplanet community as well. The exoplanet community at Michigan, from what I have learned about your program, sounds like just the kind of learning and research atmosphere I am looking for in a Ph.D program. I am committed to pursuing exoplanet research, and I am very flexible and open to adjusting the course of my Ph.D work. I do hope to be able to pursue my Ph.D at Michigan for all of the reasons I have listed above, in addition to the appeal of living in Ann Arbor. Thank you for considering my application to your prestigious research institution. My research, cv, and bio can also be found at www.loganpearcescience.com.

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I began a **second bachelor's degree in astronomy and physics** at the University of Texas at Austin in 2015. Because I entered with the goal of becoming an astronomy researcher, I immediately set about the process of obtaining as many skills and diverse set of experiences as possible. I began with a job in the Hobby-Eberly Telescope Dark Energy Experiment instrumentation laboratory, assembling the units of the VIRUS instrument for UT's ambitious research project to measure the expansion rate of the universe. During my first summer I participated in a Research Experience for Undergraduates (REU) at Northern Arizona University (NAU) in the field of planetary science.

Working with Dr. Jennifer Hanley in NAU's Astrophysical Ices Laboratory, I carried out a laboratory experiment to measure the freezing points of various liquid mixtures which could compose the lakes on the moon Titan, to determine if it is possible for the lakes to freeze during Titan's seasonal variations. I spent this past summer with the Berkeley SETI Research Center at the University of California Berkeley, on the Breakthrough Listen (BL) project to search for technosignatures in primarily radio wavelengths. Working with Howard Isaacson, I developed the "1 Million Star" target list for BL's upcoming observing campaign with the MeerKAT telescope in South Africa, which will be the largest Search for Extraterrestrial Intelligence (SETI) search in history.

But the most impactful research experience was my work Dr. Adam Kraus on **an orbit study of the wide planetary mass companion GSC 6214-210 b.** Dr. Kraus' program has been monitoring several of these type of companions for many years with images from the Keck Telescope, enough time to measure orbital motion. Planetary mass companions (PMCs) are large companions ($\sim$13 M_{jup}) on wide orbits ($\geq$100 AU) from their hosts that have been detected in imaging of young systems. I find PMCs exceedingly interesting because they occupy a parameter space that is difficult to explain with current brown dwarf and planetary formation mechanisms. In my own work on the PMC system GSC 6214-210, I measured the astrometric relative motion of GSC 6214-210 b, fit Keplerian orbital parameters to the motion, and studied the fit for clues which could point to formation mechanism. To measure the astrometry, I built my own Markov Chain Monte Carlo (MCMC) Point Spread Function fitting algorithm. To fit orbital parameters to the astrometry, I built my own rejection sampling fitting algorithm based on the methods of Orbits for the Impatient (Blunt et al., 2017). My first-author paper of my findings has been submitted to the Astrophysical Journal for publication. I concluded that the $\sim$14.5 M_{jup} companion was unlikely to have formed at a close radius, where the protoplanetary disk is thicker, and then been scattered out to its current wide orbit through a dynamical scattering interaction. This is in agreement with findings about some wide PMC systems (e.g. Bryan et al. (2016)) but not others (e.g. Ginski et al. (2014)). Thus there does not appear to be a clear trend among these objects suggesting a common formation pathway.

Study of these systems is hampered by the exceedingly small population that is known today. Bowler (2016) determined the occurrence rate of planets (5-13 M_{jup}) at separations observable in imagining (30-300 AU) to be only $0.6^{+0.7}_{-0.5}\%$. But in addition to studying population statistics for these systems, direct imaging of giant planet companions is a valuable tool for study of extrasolar planets because of the ability to study the planet directly, rather than through its influence on the host star. These valuable systems are being used to inform planetary evolutionary models, distinguish between planet formation pathways, and determine the dependence of atmospheric clouds on mass and age. However, more giant planets are needed to develop meaningful statistical characterization of this population group and their host stars, and understand them as outcome of the planet formation process. With such a low occurrence rate, direct imagining survey strategies must be optimized to select targets that maximize the likelihood of finding a giant planet or brown dwarf companion.

This led me to propose a project for the NSF Graduate Research Fellowship Program to use multi-epoch astrometry to optimize a target list to detect new directly imaged companions. As recent studies have shown (Snellen & Brown (2018), Bowler et al. (2018), Calissendorff & Janson (2018)), the large time baseline between *Hipparcos* and *Gaia* astrometry allows for detection of long period accelerations due to the presence of a companion of a wide orbit. Thus, by comparing the two epochs, I proposed to look for stars experiencing acceleration, and develop a target list optimized to identify companions based on the magnitude of the acceleration (to be consistent with planet masses), stellar multiplicity (to rule out binary systems), distance (closer objects will have larger angular separations), and age of host star (younger planets will be brighter). I then proposed to follow up the target list of $\sim$50 targets,which is the upper end of the number of targets that could reasonably be surveyed during my PhD tenure, with a high-contrast imaging survey to detect the companions.

The University of Arizona is an ideal institution to carry out this study. Your institution comes highly recommended to me as a hub for exoplanet research. The access to observing resources at Arizona is unparalleled, and facilities such as the LBTO, VLT, and Mag-AO are at the cutting edge of high-contrast imaging and interferometry. My undergraduate work was conducted using NIRC2 data from Keck Telescope, and I even was able to travel to Keck with Dr. Kraus in 2017 to collect more data for my project, and fell in love with observing there. I would ideally like to continue to pursue high contrast imaging and a career as an observational astronomer.

However the main reason I would like to study at Arizona is the expertise of your exoplanet community. I attended the Star and Planet Formation 2 conference in March of 2018, and met many of your faculty and graduate students, and learned about the exciting research in both theory and observations of how star and planetary systems form. I am particularly interested in the work of Daniel Apai's research group. His student Yifan Zhou recently visited UT Austin, and his presentation was exciting and directly related to my undergraduate research, and we discussed all of the work Dr. Apai's group is doing related to planetary mass companions. I feel that my research experience and interests would be an asset to his group, and his expertise at planet searching with VLT, access to resources, and mentorship would be vital to my science and growth as an astronomer. Jared Males and the Mag-AO team are very interesting to me as well.

Additionally, your department comes highly recommended to me as a supportive and encouraging learning environment. The exoplanet community at Arizona, from what I have learned about your program, sounds like just the kind of learning and research atmosphere I am looking for in a Ph.D program. I am also a hiking enthusiast and love the desert, so living in Tucson is very appealing to me as well.

I am excited about the project I have proposed for NSF funding, and how well it would be served at Arizona, however **I am open to other exciting research ideas as well.** I am committed to pursuing exoplanet research, and I very much enjoyed the high contrast imaging work I have done previously, and would like to continue in it. But I know that plans have a high likelihood of changing, and I am very flexible and open to adjusting the course of my Ph.D work. I do hope to be able to pursue my Ph.D at Arizona for all of the reasons I have listed above. Thank you for considering my application to your prestigious research institution. My research, cv, and bio can also be found at www.loganpearcescience.com.

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