Michigan ELT Fellowship

Steward Observatory
933 N. Cherry Ave.
Tucson, AZ 85721

THE UNIVERSITY OF ARIZONA

Tel: (520) 621-2288
loganpearce1@arizona.edu

December 1, 2023

Subject: Michigan ELT Fellowship Cover Letter

I intend to pursue a career as an observational astronomer in the field of high-contrast imaging and exoplanet science. I propose to build on my experience modeling exoplanet reflected light spectra by applying my models to ELT/HARMONI and ELT-PCS instruments to predict survey yields, estimate spectroscopic atmosphere characterization, and inform instrument design and observing strategies. This proposal will be a key piece of planning for one the main science cases of the next generation of ground-based astronomy.

I began this work during my PhD at the University of Arizona with the MagAO-X team. Working with Natasha Batalha at NASA Ames, I produced a suite of reflected light models, called ReflectX, which I applied to planning MagAO-X reflected light observations expected in the next few years, and to the Preliminary Design Review of GMagAO-X, the follow-on instrument the team is building for GMT (PDR will be in Spring 2024). This work is ongoing and publication is planned for Spring 2024. With the support of this fellowship I will continue this exciting and important work with ELT instruments, continue to work with MagAO-X and GMagAO-X team on reflected light observations, and continue to develop and improve the ReflectX model suite through collaboration with folks at Michigan, NASA, and beyond.

Additionally, locating my postdoc fellowship at Michigan allows me to continue my white dwarf - main sequence star binary survey called the Pup Search, novel research benefiting both the exoplanet and white dwarf science communities. My program uses ground-breaking new ground-based telescope high-contrast imaging instrumentation to detect new white dwarf companions to main sequence stars and study the pollution rates of white dwarfs in wide binary systems compared to single white dwarfs, in order to study the influence of the wide companion on planets and planetesimals around the white dwarf, and to enable population-level statistics by uncovering new systems. This survey relies on MagAO-X on the Magellan Clay telescope, of which Michigan is a consortium member.

Finally, with the support of this fellowship I will build on my previous work to continue to serve my student veteran community and encourage veteran participation in STEM research through the Student Veterans Research Symposium. Student veteran participation and graduation rates in STEM fields lags their non-veteran peers. Veterans face several barriers to success in STEM degrees not faced by non-veteran students, and are more likely to come from traditionally underrepresented groups in STEM such as first-generation college students and racial minorities. In my Future Plans section, I discuss how a veteran-specific research symposium will help encourage participation in STEM research at Michigan-area schools.

In summary, the research program I am proposing is ideally suited to the resources provided by this fellowship and will be a significant impact to the next generation of exoplanet science, and the support of this fellowship will be vital for accomplishing my professional and outreach goals.

Logan A Pearce

RESEARCH PROPOSAL

Preparing for the Next Generation of Exoplanet Science: Reflected Light Spectroscopic Modeling for Extreme AO in the ELT Era

MOTIVATION: The Astro 2020 decadal survey listed detecting and characterizing Earth-like exoplanets and potentially habitable worlds as one of the top three scientific priorities for the next decade of astronomy. To date, all directly imaged exoplanets have been detected in their thermal emission, limiting the systems probed by this method to young, large planets on wide separations from their host stars. To directly image an Earth-like or potentially habitable exoplanet, it is necessary to detect them in the light they reflect from their host star. The contrasts inherent in these detections have been prohibitively high, but technology platforms like the extreme AO (ExAO) instrument MagAO-X on the Magellan Clay Telescope are pushing technology like AO system design, wavefront control, and post-processing techniques to necessary regimes, and the first reflected light exoplanet detections with MagAO-X are expected in the next few years. The next generation of 30-m class telescopes is poised to directly image hundreds of exoplanets in reflected light and provide detailed specra of their atmospheres.

As first light with the first of these telescopes is approaching, now is the time to prepare for these observations and understand what can be learned about these exoplanets and what instrument designs are needed to maximize scientific yield. In 2023 I spent 6 months on an NSF INTERN-funded internship at NASA Ames Research Center working with Natasha Batalha, the PI of the Picaso radiative transfer exoplanet modeling package [2], to produce the ReflectX model grid of reflected light planets. ReflectX[1] consists of two generic planet model grids spanning a wide range of star and planet properties for gas giant and terrestrial planets, and provides 1d reflected light spectra in the range of 0.4-2 μm. ReflectX also contains models of the nearest known RV-detected exoplanets. I am currently working with this model grid to predict survey yields for reflected light imaging with MagAO-X, and to inform the design of GMagAO-X, the first light ExAO coronagraphic instrument for the Giant Magellan Telescope (GMT). Preliminary Design Review for GMagAO-X is planned for spring 2024, and the analysis using ReflectX models will be a key part of the design and review. Figure 1 displays a preliminary example of an exposure time estimate using ReflectX models. It shows three known nearby gas giant exoplanets modeled using ReflectX combined with a noise model based on Males et al. 2021 [7] Sec 2 for GMagAO-X on the Giant Magellan Telescope (see caption for details). We see that all three planets are detectable (S/N $>$ 5) in most filters in less than an hour exposure time. This is an example of the type of analysis proposed for this fellowship. This analysis for GMT/GMagAO-X is ongoing at this time.

PROPOSAL: **I propose to apply the ReflectX model suite to the European Extremely Large Telescope (E-ELT) instruments ELT-PCS and HARMONI to assess capabilities and science yield and inform the design of of both instruments.** The extreme AO coronagraphic

[1] https://reflectx.readthedocs.io/en/latest/index.html

[3] https://jaredmales.github.io/mxlib-doc/group__planets.html#ga4b350ecfdeaca1bedb897db770b09789

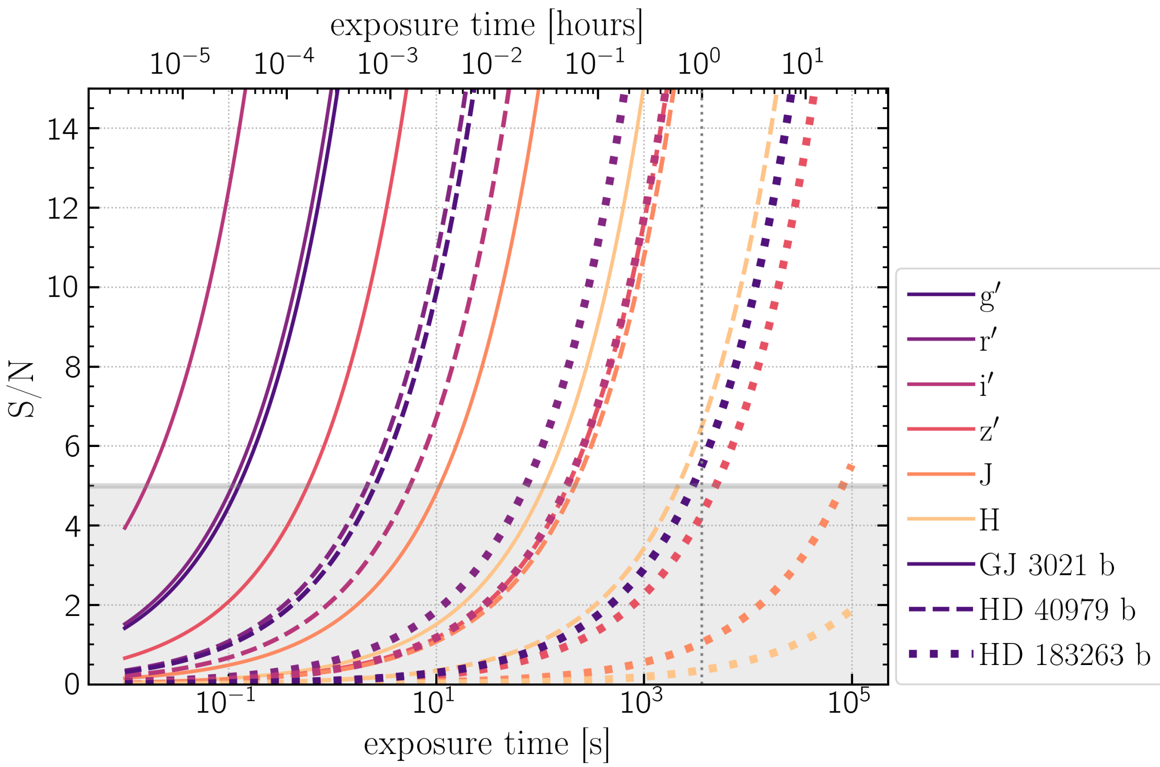


Figure 1: *Exposure time vs signal-to-noise (S/N) in SDSS and MKO filters for preliminary ReflectX models of three known nearby gas giant planets, all with* $R \approx 11R_{\oplus}$ *at 18, 34, and 55 pc respectively, for GMagAO-X on the Giant Magellan Telescope (diameter = 25.4 m). Photometric signal was estimated using ReflectX output of Picaso climate calculation and combined with the filter transmission curve. The noise model was adapted from Males et al. 2021 [7] Sec 2, which assumes an atmospheric-speckle dominated regime. Where unknown, radius was derived using an exoplanet mass-radius relation[3] and RV minimum mass estimate. The grey shaded region marks S/N* $<$ *5, which is typically considered a non-detection. The dashed grey line marks exposure time of 1 hour. All three planets are easily detected photometrically in most filters in less than an hour of exposure time.*

photometric and spectroscopic instrument ELT-PCS, along with GMagAO-X, is poised to make the biggest impact in this science case so careful modeling and planning is essential to informing design to maximize science capabilities and yields. The ReflectX model suite is already being used for this for GMagAO-X, and can easily be applied to both HARMONI and ELT-PCS characterization. All of this is being tested right now on MagAO-X, which the University of Michigan (UM) is invested in, and with which I have a demonstrated history of impactful science. As part of this proposal I will continue to collaborate with the MagAO-X team as a key partner in reflected light survey design and observations with both MagAO-X and GMagAO-X. I plan to work with Michael Meyer on this program, one of the significant users of MagAO-X and invested in E-ELT instrumentation. The funding of this fellowship will allow me carry out this vital project at UM.

In Year 1 of my fellowship I will combine ReflectX models with ELT-PCS and HARMONI noise models to produce survey yield predictions and atmospheric signal detection predictions using the two generic planet grids, with publication of survey design expected near the end of Year 1. I will also continue to work with GMagAO-X and my collaborators at the University of Arizona to produce robust analysis and deliver near-term impacts to the US exoplanet ELT community. In Years 2 and 3 of my fellowship I will work with exoplanet atmosphere experts at Michigan, such as Ryan MacDonald (with whom I've collaborated on analysis of JWST observations of WD 1856 b [16]) and my collaborators at University of Arizona, UCSC, and NASA Ames to continue to improve the ReflectX model grids and investigate more and diverse planetary atmosphere characteristics, such as the influence of disequilibrium chemistry, tidal heating and thermal emission, and the influence of hazes. I will continue to expand the public-facing interface of ReflectX to enable community use of the models with a wide range of telescopes and instruments. I expect multiple publications resulting from these analyses. Throughout the fellowship term I will collaborate with the MagAO-X team to design and carry out the planned reflected light observations in the next few years.

The short-term outcomes of this fellowship will be the first ground-based reflected light observations with MagAO-X, an analysis of the capabilities of GMagAO-X, HARMONI, and design input for ELT-PCS on this key science case, and a robust public model suite with an effective public interface.

Summary of Previous and Current Research

This proposal builds on my past research in both reflected light modeling and high contrast imaging with extreme AO instruments and is a natural extension of expertise, experience, and collaborations developed during my PhD at the University of Arizona.

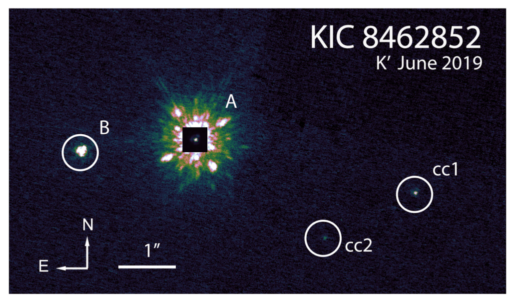


Figure 2: *Figure 1 of Pearce et al. 10 showing Boyajian's Star, marked A, with the confirmed companion, marked B, 2" to the east.*

Previous research #1: The wide stellar companion to Boyajian's Star: The transit light curve of Boyajian's Star (aka KIC 8462852) exhibits large aperiodic dips in a variety of shapes that are inconsistent with any astrophysical explanation [4]. In **Pearce et al. 2021** [10], we used three epochs of Keck/NIRC2 infrared imaging with adaptive optics (AO) to show that a candidate wide stellar companion at 880 AU (shown in Figure 2) is gravitationally bound, and argued that it is possible that the companion's gravity is or recently was influencing the planetary regime even at such a large distance.

Previous research #2: Binary Differential Imaging and the HIP 67506 AC system: One method for removing the stellar PSF in AO imaging is to image a reference star that does not contain a companion signal, and use it to model the stellar PSF and subtract from the science target star. In **Pearce et al. 2022** [11], I analyzed infrared images of 17 wide stellar binaries, obtained from 2015-2017 with MagAO [5] on the Magellan Clay Telescope, using each star in the binary as the reference star for the other, called Binary Differential Imaging [BDI; 14]. HIP 67506 A contained a candidate signal at $\sim$ 2" (Figure 3, top).

We observed HIP 67506 A in April 2022 with the MagAO-X instrument on the Magellan Clay Telescope and easily confirmed the companion signal, HIP 67506 C, at 0.1" (Figure 3, bottom). We characterized the HIP 67506 AC system with our photometry and astrometry in **Pearce et al. 2023** [12]. This was the first MagAO-X paper published using on-sky data.

Current Research Project #1: Accelerating Stars with MagAO-X: The 25-year astrometric baseline provided by the Hipparcos and Gaia satellites provides a way to identify stars experiencing long-period accelerations due to a hidden companion. I am Co-PI on a survey of accelerating stars in the young Scorpius Centaurus star forming region with MagAO-X, called Xoomies, to discover new giant planet and brown dwarf companions to young stars. The first Xoomies observations are planned for Spring 2024.

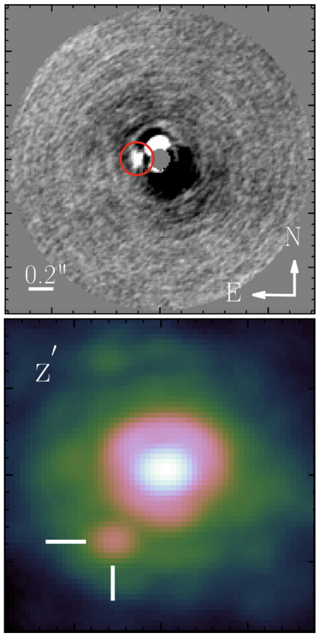


Figure 3: *Top: L' BDI-reduced image of HIP 67506 A with candidate signal marked in red. Bottom: MagAO-X z' with companion HIP 67506 C marked by white cross*

Current Research Project #2: ExAO Pup Search: The influence of a wide stellar companion on exoplanets around a star is crucial to probe for understanding how planets in binaries form and evolve. Observational tests are critical for predictions of how and to what degree companions influence planetary systems throughout the star's lifetime. White dwarfs (WD) with (non-interacting) main sequence star companions (WDMS) are an excellent laboratory for probing the influence of a wide companion at late stages of planetary system evolution. WDs are expected to have pure H/He photospheres, and it has been shown that any metals observed in their spectra were deposited recently from the planetary regime [19], making "polluted" WDs the only method of probing the refractory compositions of exoplanetary material [e.g. 20, 17, 21, 13]. The role of a wide companion in deposition of material onto the WD is unknown and hampered by low population statistics. I am currently conducting the ExAO Pup Search: a survey to probe planets in wide binaries by leveraging the power of extreme adaptive optics towards White Dwarf + Main Sequence star systems[4].

The Pup Search has three main objectives:

1. Detect new non-interacting WDMS binary systems with MagAO-X on the Magellan Clay Telescope and SCExAO on Subaru Telescope.

2. Monitor orbits of new and previously known resolved WDMS systems with imaging and radial velocity to determine prevalence of high-eccentricity orbits of MS companions for polluted WDs and compare to estimated orbital parameters for the binary to be influencing pollution, such as those in Stephan et al. [15] and Veras et al. [18] Fig 3.

3. Determine pollution rates for WDMS systems with Keck/HIRES and HST, compare to single WDs and as a function of cooling age, and compare to estimates such as Veras et al. [19]

The first Pup Search observations were conducted in fall 2022 with MagAO-X on the Magellan Clay Telescope, with one new WDMS detection, shown in Figure 4. Another MagAO-X observation of the Pup Search target list will occur in Spring 2024. This survey will provide the **exoplanet community** with a robust investigation of S-type planets in binaries at the end of the star's lifetime, with new WD pollution data providing more evidence of refractory compositions of exoplanets, and provide the **white dwarf community** with an expanded population of WDMS systems. These data produced by this survey will be invaluable to both fields.

Current Research Project #3: Exoplanets in Reflected Light with GMT and GMagAO-X: A detailed above, in 2023 I won funding through the NSF INTERN program to spend 6 months

[4] The name is a reference to the first known wide White Dwarf- Main Sequence system, Sirius AB discovered in 1844 by Friedrich Bessel when he observed changes in the proper motion of Sirius [3], first observed by Alvin Graham Clark [6], and confirmed as the second ever known WD via its spectrum obtained by Walter Adams [1]. Since Sirius A is the "Dog Star", Sirius B was nicknamed "The Pup"

at NASA Ames Research Center to work with Dr. Natasha Batalha, an expert in exoplanet atmosphere modeling. I am using the exoplanet atmosphere modeling code Picaso [2], which she maintains, to to produce the ReflectX model reflected light spectra of hundreds of star and planet configurations and combine them with noise models to produce signal-to-noise and exposure time estimates for broadband and high-resolution spectroscopic observations of exoplanets in reflected light, particularly for upcoming MagAO-X and GMagAO-X reflected light surveys. ReflectX models are being made public for the DI community working on ground-based reflected light exoplanet imaging, and are contributing to the design of GMagAO-X and GMT. ReflectX is open-source, maintained publicly on GitHub, with extensive documentation in accordance with software best practices.

Outreach #1: Veteran Outreach: My status as a student veteran has been a significant part of my identity as a researcher. I am motivated to help my student veteran peers make the most of the opportunities available in undergraduate and graduate programs. As a PhD student at the University of Arizona I worked for three summers as a Research Project Leader for the Warrior Scholar Program (WSP), conducting week-long projects introducing scientific research and coding as part of WSP's two week "boot camp" for veterans transitioning into undergraduate programs. In 2022-2023 I worked for a full academic year as a consultant for WSP's Diana Davis Spencer Scholars program in which I gave workshops, shared resources, and gave application material feedback for a cohort of 25 WSP alumni who were applying for graduate school. I created and presented three professional development workshops with DDSS, and three different research projects with WSP, all of which are publicly available on my website and GitHub. Finally in 2021 I founded of the Student Veterans Research Network (SVRN), a peer network of graduate student veterans connecting across disciplines and across the country to support each other and share resources. In 2022 I presented SVRN at the Student Veterans of America National Conference in Orlando, FL.

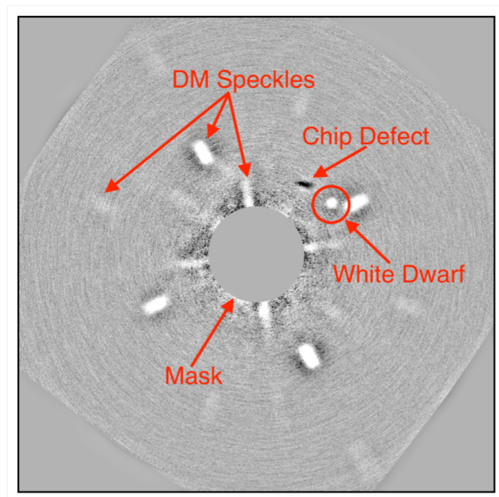


Figure 4: *A new WD companion (red circle) to a main sequence star discovered in i' band with MagAO-X in 2022 as part of the Pup Search program. Host star PSF was removed by unsharp mask and radial profile subtraction; mask, chip defect, and speckles caused by the deformable mirror are labeled. The new WD companion is indicated by the red circle.*

I am currently starting the annual Student Veteran Research Symposium to showcase veteran research at the undergraduate, graduate, and post-doc levels and encourage recruitment and retention of veterans into STEM research. I have developed a detailed plan for the Symposium with my PhD advisor Dr. Jared Males (also a Navy veteran) and have begun the initial work to host a local Symposium for Arizona schools this upcoming spring at UA.

Outreach #2: Astronomy on Tap Tucson: Since 2021 I have served as Lead Organizer for Astronomy on Tap (AoT) in Tucson. AoT is a worldwide organization of local public astronomy outreach talks in bars and breweries. In Tucson we operate as Space Drafts and host public talks every month at a local brewery. We have a robust program of talks, trivia, games, and merchandise and see a loyal audience month after month. I lead a team of six to put on the show in a relaxed atmosphere making the cutting edge astronomy happening in Tucson accessible and fun to a public audience. I love AoT and intend to participate in the Ann Arbor show if awarded this fellowship.

Additional Plans for This Fellowship

Continuation of the Pup Search: Locating my postdoc at Michigan has the added benefit of enabling the continuation of the Pup Search survey described above. As described in the previous section, the Pup Search targets new and known non-interacting white dwarf + main sequence binaries in an effort to obtain new population members and understand how the wide companion influences the planetary regime around the white dwarf. This survey relies heavily on data from the MagAO-X instrument on the Magellan Telescope, of which Michigan is a consortium member. The Pup Search also relies on access to SCExAO, Keck, and HST, all of which I plan to apply for through public time allocations. As a member of the MagAO-X team during my PhD I have had 24 hours MagAO-X observing time as PI awarded over 2 semesters, 18 of which were for preliminary Pup Search observations. The remaining 6 hours resulted in publication of a new binary system HIP 67506 AC [12]. Additional MagAO-X Pup Search observations are planned for Spring 2024. I have extensive experience with long-period orbit monitoring [8, 9, 10] and with high-contrast image processing and data analysis [11, 12], so I am well qualified to carry out this project during my postdoc tenure.

Student Veterans Research Symposium with Michigan Area Universities: Finally, I intend to continue my outreach to the student veteran population during my postdoc tenure. Veterans are a statistically underrepresented group in higher education despite the numerous education benefits accompanying veteran status. Veterans are 7% of the US population over 18, yet they make up 3.7% of undergraduate students at the University of Arizona (UA), and 3.6% of STEM majors. At UA, veteran retention also lags compared to all students, with 31% of veteran STEM majors graduating after 6 years compared to 63% of all undergraduates[5]. The veteran population disproportionately comes from other underrepresented groups as well, such as racial minorities and first-generation college students. Veterans are significantly more likely to have dependents, military reserve obligations, and specific requirements related to education benefits (e.g. needing to take a full course load in order to receive a housing stipend), all of which can limit access to the kinds of opportunities that make graduate school applications stand out.

Veterans often don't realize how their military experience can be applied to STEM academics and careers. In addition to technical skills, veterans tend to underestimate the "soft skills" they've attained in the service, such as leadership and management, and how they can be leveraged for academic and research success. Many student veterans I've known were nervous about how their age and life experience makes them different from their college peers, something which actually is a major strength.

	Year 1			Year 2			Year 3		
	Fall 24	Spr 25	Sum 25	Fall 25	Spr 26	Sum 26	Fall 26	Spr 27	Sum 27
Local symposium for host institution and local community colleges		X							
Regional symposium including school from neighboring states					X				
National symposium								X	

Figure 5: *Symposium timeline*

[5]Source: UA Analytics as of 2020

Getting STEM-inclined veterans involved in STEM research in undergrad can increase retention by (1) helping them see past barriers such as difficult classes, (2) fostering community in academia by becoming contributing members of a research group, mitigating perceptions of otherness due to age and life-stage differences with peers, (3) fostering a sense of purpose by contributing meaningfully to active research, and (4) utilizing skills from service in a new way or uncovering new skills.

Budget	
Keynote speaker travel and accomodation	$1,000
Coffee, lunch, snacks throughout day	$1,000
Conference dinner/reception	$2,000
Total	$4,000

Figure 6: *Example Symposium budget for the first local Symposium.*

I propose to start the annual Veterans Research Symposium at the University of Michigan, a student veteran focused scientific research conference showcasing the research produced by veterans across disciplines at undergraduate, graduate, and post-doc levels. Together with my PhD advisor at UA, Dr. Jared Males (also a US Navy veteran), we have already begun the work of refining this idea and taking the first steps at the University of Arizona; I will extend this to UM and Michigan-area schools. The goal of the conference is to **promote community** among student veterans across disciplines, **increase visibility** of veteran researchers and encourage recruitment into research, **enable connection** for graduate programs looking to recruit student veterans, and **showcase the skills and achievements of veterans in STEM** research to encourage recruitment and retention of veterans. Taking place over two days, the conference will consist of multiple poster and/or talk sessions, workshops, and a keynote speaker. We plan to begin with local area universities initially, building eventually to a national conference. Figure 1 displays a proposed timeline; Figure 2 displays an example budget for the first local Symposium. We will work closely with UM and veteran groups to fund the initial Symposium, and build on its success to expand funding for the larger events. We will track participation rates by veteran researchers, as well as attendance by non-veterans to assess the utility of this symposium. **If funded through the Michigan ELT Fellowship, I will continue this work with Dr. Males to make this dream a reality.**

References

[1] W. S. Adams. The Spectrum of the Companion of Sirius. *Pub. of the Astron. Soc. of the Pac.*, 27(161):236, Dec. 1915. doi: 10.1086/122440.

[2] N. E. Batalha, M. S. Marley, N. K. Lewis, and J. J. Fortney. Exoplanet Reflected-light Spectroscopy with PICASO. *Astrophys J.*, 878(1):70, June 2019. doi: 10.3847/1538-4357/ab1b51.

[3] F. W. Bessel. On the variations of the proper motions of Procyon and Sirius. *Mon. Not. R. Astron. Soc.*, 6: 136–141, Dec. 1844. doi: 10.1093/mnras/6.11.136.

[4] T. S. Boyajian, D. M. LaCourse, S. A. Rappaport, D. Fabrycky, D. A. Fischer, D. Gandolfi, G. M. Kennedy, H. Korhonen, M. C. Liu, A. Moor, K. Olah, K. Vida, M. C. Wyatt, W. M. J. Best, J. Brewer, F. Ciesla, B. Csák, H. J. Deeg, T. J. Dupuy, G. Handler, K. Heng, S. B. Howell, S. T. Ishikawa, J. Kovács, T. Kozakis, L. Kriskovics, J. Lehtinen, C. Lintott, S. Lynn, D. Nespral, S. Nikbakhsh, K. Schawinski, J. R. Schmitt, A. M. Smith, G. Szabo, R. Szabo, J. Viuho, J. Wang, A. Weiksnar, M. Bosch, J. L. Connors, S. Goodman, G. Green, A. J. Hoekstra, T. Jebson, K. J. Jek, M. R. Omohundro, H. M. Schwengeler, and A. Szewczyk. Planet Hunters IX. KIC 8462852 - where's the flux? *Mon. Not. R. Astron. Soc.*, 457(4):3988–4004, Apr. 2016. doi: 10.1093/mnras/stw218.

[5] L. M. Close, J. R. Males, K. Morzinski, D. Kopon, K. Follette, T. J. Rodigas, P. Hinz, Y. L. Wu, A. Puglisi, S. Esposito, A. Riccardi, E. Pinna, M. Xompero, R. Briguglio, A. Uomoto, and T. Hare. Diffraction-limited

Visible Light Images of Orion Trapezium Cluster with the Magellan Adaptive Secondary Adaptive Optics System (MagAO). *Astrophys J.*, 774(2):94, Sept. 2013. doi: 10.1088/0004-637X/774/2/94.

[6] C. Flammarion. The Companion of Sirius. *Astronomical register*, 15:186–189, Jan. 1877.

[7] J. R. Males, M. P. Fitzgerald, R. Belikov, and O. Guyon. The Mysterious Lives of Speckles. I. Residual Atmospheric Speckle Lifetimes in Ground-based Coronagraphs. *Pub. of the Astron. Soc. of the Pac.*, 133(1028): 104504, Oct. 2021. doi: 10.1088/1538-3873/ac0f0c.

[8] L. A. Pearce, A. L. Kraus, T. J. Dupuy, M. J. Ireland, A. C. Rizzuto, B. P. Bowler, E. K. Birchall, and A. L. Wallace. Orbital Motion of the Wide Planetary-mass Companion GSC 6214-210 b: No Evidence for Dynamical Scattering. *Astronom. J.*, 157(2):71, Feb. 2019. doi: 10.3847/1538-3881/aafacb.

[9] L. A. Pearce, A. L. Kraus, T. J. Dupuy, A. W. Mann, E. R. Newton, B. M. Tofflemire, and A. Vanderburg. Orbital Parameter Determination for Wide Stellar Binary Systems in the Age of Gaia. *Astrophys. J.*, 894(2):115, May 2020. doi: 10.3847/1538-4357/ab8389.

[10] L. A. Pearce, A. L. Kraus, T. J. Dupuy, A. W. Mann, and D. Huber. Boyajian's Star B: The Co-moving Companion to KIC 8462852 A. *Astrophys. J.*, 909(2):216, Mar. 2021. doi: 10.3847/1538-4357/abdd33.

[11] L. A. Pearce, J. R. Males, A. J. Weinberger, J. D. Long, K. M. Morzinski, L. M. Close, and P. M. Hinz. Companion mass limits for 17 binary systems obtained with binary differential imaging and MagAO/Clio. *Mon. Not. R. Astron. Soc.*, 515(3):4487–4504, Sept. 2022. doi: 10.1093/mnras/stac2056.

[12] L. A. Pearce, J. R. Males, S. Y. Haffert, L. M. Close, J. D. Long, A. L. McLeod, J. M. Knight, A. D. Hedglen, A. J. Weinberger, O. Guyon, M. Kautz, K. Van Gorkom, J. Lumbres, L. Schatz, A. Rodack, V. Gasho, J. Kueny, W. Foster, K. M. Morzinski, and P. M. Hinz. HIP 67506 C: MagAO-X confirmation of a new low-mass stellar companion to HIP 67506 A. *Mon. Not. R. Astron. Soc.*, 521(3):4775–4784, May 2023. doi: 10.1093/mnras/stad859.

[13] K. D. Putirka and S. Xu. Polluted white dwarfs reveal exotic mantle rock types on exoplanets in our solar neighborhood. *Nat. Commun.*, 12:6168, Nov. 2021. ISSN 2041-1723. doi: 10.1038/s41467-021-26403-8.

[14] T. J. Rodigas, A. Weinberger, E. E. Mamajek, J. R. Males, L. M. Close, K. Morzinski, P. M. Hinz, and N. Kaib. Direct Exoplanet Detection with Binary Differential Imaging. *Astrophys J.*, 811(2):157, Oct. 2015. doi: 10.1088/0004-637X/811/2/157.

[15] A. P. Stephan, S. Naoz, and B. Zuckerman. Throwing Icebergs at White Dwarfs. *Astrophys. J. Let.*, 844(2):L16, Aug. 2017. doi: 10.3847/2041-8213/aa7cf3.

[16] A. Vanderburg, S. A. Rappaport, S. Xu, I. J. M. Crossfield, J. C. Becker, B. Gary, F. Murgas, S. Blouin, T. G. Kaye, E. Palle, C. Melis, B. M. Morris, L. Kreidberg, V. Gorjian, C. V. Morley, A. W. Mann, H. Parviainen, L. A. Pearce, E. R. Newton, A. Carrillo, B. Zuckerman, L. Nelson, G. Zeimann, W. R. Brown, R. Tronsgaard, B. Klein, G. R. Ricker, R. K. Vanderspek, D. W. Latham, S. Seager, J. N. Winn, J. M. Jenkins, F. C. Adams, B. Benneke, D. Berardo, L. A. Buchhave, D. A. Caldwell, J. L. Christiansen, K. A. Collins, K. D. Colón, T. Daylan, J. Doty, A. E. Doyle, D. Dragomir, C. Dressing, P. Dufour, A. Fukui, A. Glidden, N. M. Guerrero, X. Guo, K. Heng, A. I. Henriksen, C. X. Huang, L. Kaltenegger, S. R. Kane, J. A. Lewis, J. J. Lissauer, F. Morales, N. Narita, J. Pepper, M. E. Rose, J. C. Smith, K. G. Stassun, and L. Yu. A giant planet candidate transiting a white dwarf. *Nat.*, 585 (7825):363–367, Sept. 2020. doi: 10.1038/s41586-020-2713-y.

[17] D. Veras. Post-main-sequence planetary system evolution. *Royal Society Open Science*, 3:150571, Feb. 2016. doi: 10.1098/rsos.150571.

[18] D. Veras, N. Georgakarakos, I. Dobbs-Dixon, and B. T. Gänsicke. Binary star influence on post-main-sequence multi-planet stability. *Mon. Not. R. Astron. Soc.*, 465:2053–2059, Feb. 2017. ISSN 0035-8711. doi: 10.1093/mnras/stw2699.

[19] D. Veras, S. Xu, and A. Rebassa-Mansergas. The critical binary star separation for a planetary system origin of white dwarf pollution. *Mon. Not. R. Astron. Soc.*, 473:2871–2880, Jan. 2018. ISSN 0035-8711. doi: 10.1093/mnras/stx2141.

[20] S. Xu and A. Bonsor. Exogeology from Polluted White Dwarfs. *Elements*, 17(4):241, Aug. 2021. doi: 10.48550/arXiv.2108.08384.

[21] B. Zuckerman, D. Koester, C. Melis, B. M. Hansen, and M. Jura. The Chemical Composition of an Extrasolar Minor Planet. *Astrophys. J.*, 671(1):872–877, Dec. 2007. doi: 10.1086/522223.

PUBLICATIONS

FIRST AUTHOR

- **Pearce, L. A.**, Males, J. R., Haffert, S. Y., Close, L. M., Long, J. D., et al. (2023) HIP 67506 C: MagAO-X confirmation of a new low-mass stellar companion to HIP 67506 A *Monthly Notices of the Royal Astronomical Society 521*, 4775

- **Pearce, L. A.**, Males, J. R., Weinberger, A. J., Long, J. D., Morzinski, K. M., et al. (2022) Companion mass limits for 17 binary systems obtained with binary differential imaging and MagAO/Clio *Monthly Notices of the Royal Astronomical Society 515*, 4487

- **Pearce, L. A.**, Kraus, A. L., Dupuy, T. J., Mann, A. W., Huber, D. (2021) Boyajian's Star B: The Co-moving Companion to KIC 8462852 A *The Astrophysical Journal 909*, 216

- **Pearce, L. A.**, Kraus, A. L., Dupuy, T. J., Mann, A. W., Newton, E. R., et al. (2020) Orbital Parameter Determination for Wide Stellar Binary Systems in the Age of Gaia *The Astrophysical Journal 894*, 115

- **Pearce, L. A.**, Kraus, A. L., Dupuy, T. J., Ireland, M. J., Rizzuto, A. C., et al. (2019) Orbital Motion of the Wide Planetary-mass Companion GSC 6214-210 b: No Evidence for Dynamical Scattering *The Astronomical Journal 157*, 71

CONTRIBUTING AUTHOR

- Dupuy, T. J., Liu, M. C., Evans, E. L., Best, W. M. J., **Pearce, L. A.**, et al. (2023) On the masses, age, and architecture of the VHS J1256-1257AB b system *Monthly Notices of the Royal Astronomical Society 519*, 1688

- Venner, A., **Pearce, L. A.**, Vanderburg, A. (2022) An edge-on orbit for the eccentric long-period planet HR 5183 b *Monthly Notices of the Royal Astronomical Society 516*, 3431

- Christian, S., Vanderburg, A., Becker, J., Yahalomi, D. A., **Pearce, L.**, et al. (2022) A Possible Alignment Between the Orbits of Planetary Systems and their Visual Binary Companions *The Astronomical Journal 163*, 207

- Venner, A., Vanderburg, A., **Pearce, L. A.** (2021) True Masses of the Long-period Companions to HD 92987 and HD 221420 from Hipparcos-Gaia Astrometry *The Astronomical Journal 162*, 12

- Czech, D., Isaacson, H., **Pearce, L.**, Cox, T., Sheikh, S. Z., et al. (2021) The Breakthrough Listen Search for Intelligent Life: MeerKAT Target Selection *Publications of the Astronomical Society of the Pacific 133*, 064502

- Newton, E. R., Mann, A. W., Tofflemire, B. M., **Pearce, L. A.**, Rizzuto, A. C., et al. (2019) TESS Hunt for Young and Maturing Exoplanets (THYME): A Planet in the 45 Myr Tucana-Horologium Association *The Astrophysical Journal 880*, L17

CO-AUTHOR

- Males, J. R., Close, L. M., Haffert, S., Long, J. D., Hedglen, A. D., et al. (**Pearce, L. A.**, 6 of 18) (2022) MagAO-X: current status and plans for Phase II *Adaptive Optics Systems VIII 12185*, 1218509

- Newton, E. R., Mann, A. W., Kraus, A. L., Livingston, J. H., Vanderburg, A., et al. (**Pearce, L. A.**, 15 of 53) (2021) TESS Hunt for Young and Maturing Exoplanets (THYME). IV. Three Small Planets Orbiting a 120 Myr Old Star in the Pisces-Eridanus Stream *The Astronomical Journal 161*, 65

- Close, L. M., Males, J., Long, J. D., Van Gorkom, K., Hedglen, A. D., et al. (**Pearce, L. A.**, 23 of 26) (2020) Prediction of the planet yield of the MaxProtoPlanetS high-contrast survey for H-alpha protoplanets with MagAO-X based on first light contrasts *Adaptive Optics Systems VII 11448*, 114480U

- Males, J. R., Close, L. M., Guyon, O., Hedglen, A. D., Van Gorkom, K., et al. (**Pearce, L. A.**, 20 of 20) (2020) MagAO-X first light *Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series 11448*, 114484L

- Steckloff, J. K., Soderblom, J. M., Farnsworth, K. K., Chevrier, V. F., Hanley, J., et al. (**Pearce, L. A.**, 9 of 11) (2020) Stratification Dynamics of Titan's Lakes via Methane Evaporation *The Planetary Science Journal 1*, 26

- Vanderburg, A., Rappaport, S. A., Xu, S., Crossfield, I. J. M., Becker, J. C., et al. (**Pearce, L. A.**, 18 of 65) (2020) A giant planet candidate transiting a white dwarf *Nature 585*, 363

- Nielsen, L. D., Brahm, R., Bouchy, F., Espinoza, N., Turner, O., et al. (**Pearce, L. A.**, 7 of 77) (2020) Three short-period Jupiters from TESS. HIP 65Ab, TOI-157b, and TOI-169b *Astronomy and Astrophysics 639*, A76

- Blunt, S., Wang, J. J., Angelo, I., Ngo, H., Cody, D., et al. (**Pearce, L. A.**, 11 of 13) (2020) orbitize!: A Comprehensive Orbit-fitting Software Package for the High-contrast Imaging Community *The Astronomical Journal 159*, 89

- Cook, J. C., Dalle Ore, C. M., Protopapa, S., Binzel, R. P., Cruikshank, D. P., et al. (**Pearce, L. A.**, 26 of 28) (2019) The distribution of H_2O, CH_3OH, and hydrocarbon-ices on Pluto: Analysis of New Horizons spectral images *Icarus 331*, 148

- Mayo, A. W., Rajpaul, V. M., Buchhave, L. A., Dressing, C. D., Mortier, A., et al. (**Pearce, L. A.**, 23 of 30) (2019) An 11 Earth-mass, Long-period Sub-Neptune Orbiting a Sun-like Star *The Astronomical Journal 158*, 165

- Gaidos, E., Jacobs, T., LaCourse, D., Vanderburg, A., Rappaport, S., et al. (**Pearce, L.**, 7 of 16) (2019) Planetesimals around stars with TESS (PAST) - I. Transient dimming of a binary solar analogue at the end of the planet accretion era *Monthly Notices of the Royal Astronomical Society 488*, 4465
- Vanderburg, A., Huang, C. X., Rodriguez, J. E., Becker, J. C., Ricker, G. R., et al. (**Pearce, L. A.**, 36 of 51) (2019) TESS Spots a Compact System of Super-Earths around the Naked-eye Star HR 858 *The Astrophysical Journal 881*, L19

Logan Pearce

Graduate student | NSF Graduate Fellow | Univ of Arizona & Steward Observatory
http://www.loganpearcescience.com/
loganpearce1@arizona.edu | 904.629.0436
ORCID: 0000-0003-3904-7378; https://bit.ly/logan-pearce-publications

EDUCATION

UNIVERSITY OF ARIZONA
PhD Candidate in Astronomy
Current | Tucson, AZ
Degree expected Spring 2024

UNIVERSITY OF TEXAS AT AUSTIN
BS in Astronomy (Honors)
BS in Physics
May 2019 | Austin, TX
Cum. GPA: 3.93 / 4.0

MA in Education
August 2014 | Austin, TX
Conc. in Secondary Engineering Ed.
Cum. GPA: 3.95 / 4.0

NAVAL NUCLEAR POWER TRAINING COMMAND
Reactor Plant Operations & Theory
March 2005 - March 2006 |
Charleston, SC & Ballston Spa, NY

PURDUE UNIVERSITY
BS in Chemistry
May 2003 | W. Lafayette, IN
Cum. GPA: 3.11 / 4.0

LINKS

Website:// **loganpearcescience.com**
Github:// **github.com/logan-pearce/**
LinkedIn:// **loganpearce**
Twitter:// **@loganpearce**

WORK EXPERIENCE

UNIV. OF ARIZONA STEWARD OBSERVATORY | Graduate Research Assistant
August 2019 - Current | Tucson, AZ

- PhD candidate in astronomy with specialty in high-contrast imaging.
- Completed requirements for a master's degree in astronomy in Nov 2021.
- NSF GRFP fellow.
- NSF GRFP INTERN program supplemental funding recipient
- Assisted $\sim$20 students with NSF GRFP application preparation as a consultant with the UA GRFP Application Development Program.
- Taught exoplanet-based research projects to student veteran cohorts as part of the Warrior Scholar Project in summer 2020, 2021, and 2022.
- Taught workshops and consulted on application materials for $\sim$25 student veterans applying to graduate school via the Diana Davis Spencer Scholars program.
- Founded the Student Veteran Research Network in August 2021.

UNIV. OF TEXAS AT AUSTIN | Research Assistant + Lab Technician + Writing Center Consultant
August 2015 – August 2019 | Austin, TX

- Assisted >250 students on any piece of writing at any stage as a University Writing Center Consultant for 3 semesters.
- Assisted in all aspects of fabrication and testing of the VIRUS spectroscopic instrument for the Hobby Eberly Telescope Dark Energy Experiment for 2 semesters.

KEALING MIDDLE SCHOOL | Teacher, Physics and Engineering
Aug 2009 – May 2015 | Austin, TX

- Created and implemented accelerated physics curriculum for 6th grade.
- Developed and implemented two engineering elective courses on flight and space exploration.
- Lead a team of $\sim$20 teachers as 6th grade team leader, 2013-2015.
- Obtained master's degree in engineering education in August 2014.

US NAVY | Officer, Nuclear Power Specialist
Mar 2006 – May 2008 | USS John C. Stennis (CVN-74), Bremerton, WA

- Managed all aspects of reactor plant operations as reactor Propulsion Plant Watch Officer in both at-sea wartime and maintenance conditions.
- Managed a team of 30 mechanics maintaining potentially-contaminated reactor plant systems as Mechanical Maintenance Division Officer.

May 2003 – Mar 2005 | USS Samuel B. Roberts (FFG-58), Mayport, FL

- Managed a team of 10 electronics technicians as Combat Electronics Division Officer.
- Managed all aspects of bridge and combat center operations as Bridge and Combat Center Watch Officer.

PUBLICATIONS (REFEREED)

FIRST AUTHOR

- **Pearce, L. A.**, Males, J. R., Haffert, S. Y., Close, L. M., Long, J. D., et al. (2023) HIP 67506 C: MagAO-X confirmation of a new low-mass stellar companion to HIP 67506 A *Monthly Notices of the Royal Astronomical Society 521*, 4775

- **Pearce, L. A.**, Males, J. R., Weinberger, A. J., Long, J. D., Morzinski, K. M., et al. (2022) Companion mass limits for 17 binary systems obtained with binary differential imaging and MagAO/Clio *Monthly Notices of the Royal Astronomical Society 515*, 4487

- **Pearce, L. A.**, Kraus, A. L., Dupuy, T. J., Mann, A. W., Huber, D. (2021) Boyajian's Star B: The Co-moving Companion to KIC 8462852 A *The Astrophysical Journal 909*, 216

- **Pearce, L. A.**, Kraus, A. L., Dupuy, T. J., Mann, A. W., Newton, E. R., et al. (2020) Orbital Parameter Determination for Wide Stellar Binary Systems in the Age of Gaia *The Astrophysical Journal 894*, 115

- **Pearce, L. A.**, Kraus, A. L., Dupuy, T. J., Ireland, M. J., Rizzuto, A. C., et al. (2019) Orbital Motion of the Wide Planetary-mass Companion GSC 6214-210 b: No Evidence for Dynamical Scattering *The Astronomical Journal 157*, 71

CONTRIBUTING AUTHOR

- Dupuy, T. J., Liu, M. C., Evans, E. L., Best, W. M. J., **Pearce, L. A.**, et al. (2023) On the masses, age, and architecture of the VHS J1256-1257AB b system *Monthly Notices of the Royal Astronomical Society 519*, 1688

- Venner, A., **Pearce, L. A.**, Vanderburg, A. (2022) An edge-on orbit for the eccentric long-period planet HR 5183 b *Monthly Notices of the Royal Astronomical Society 516*, 3431

- Christian, S., Vanderburg, A., Becker, J., Yahalomi, D. A., **Pearce, L.**, et al. (2022) A Possible Alignment Between the Orbits of Planetary Systems and their Visual Binary Companions *The Astronomical Journal 163*, 207

- Venner, A., Vanderburg, A., **Pearce, L. A.** (2021) True Masses of the Long-period Companions to HD 92987 and HD 221420 from Hipparcos-Gaia Astrometry *The Astronomical Journal 162*, 12

- Czech, D., Isaacson, H., **Pearce, L.**, Cox, T., Sheikh, S. Z., et al. (2021) The Breakthrough Listen Search for Intelligent Life: MeerKAT Target Selection *Publications of the Astronomical Society of the Pacific 133*, 064502

- Newton, E. R., Mann, A. W., Tofflemire, B. M., **Pearce, L. A.**, Rizzuto, A. C., et al. (2019) TESS Hunt for Young and Maturing Exoplanets (THYME): A Planet in the 45 Myr Tucana-Horologium Association *The Astrophysical Journal 880*, L17

CO-AUTHOR

- Males, J. R., Close, L. M., Haffert, S., Long, J. D., Hedglen, A. D., et al. (**Pearce, L. A.**, 6 of 18) (2022) MagAO-X: current status and plans for Phase II *Adaptive Optics Systems VIII 12185*, 1218509

- Newton, E. R., Mann, A. W., Kraus, A. L., Livingston, J. H., Vanderburg, A., et al. (**Pearce, L. A.**, 15 of 53) (2021) TESS Hunt for Young and Maturing Exoplanets (THYME). IV. Three Small Planets Orbiting a 120 Myr Old Star in the Pisces-Eridanus Stream *The Astronomical Journal 161*, 65

- Close, L. M., Males, J., Long, J. D., Van Gorkom, K., Hedglen, A. D., et al. (**Pearce, L. A.**, 23 of 26) (2020) Prediction of the planet yield of the MaxProtoPlanetS high-contrast survey for H-alpha protoplanets with MagAO-X based on first light contrasts *Adaptive Optics Systems VII 11448*, 114480U

- Males, J. R., Close, L. M., Guyon, O., Hedglen, A. D., Van Gorkom, K., et al. (**Pearce, L. A.**, 20 of 20) (2020) MagAO-X first light *Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series 11448*, 114484L

- Steckloff, J. K., Soderblom, J. M., Farnsworth, K. K., Chevrier, V. F., Hanley, J., et al. (**Pearce, L. A.**, 9 of 11) (2020) Stratification Dynamics of Titan's Lakes via Methane Evaporation *The Planetary Science Journal 1*, 26

- Vanderburg, A., Rappaport, S. A., Xu, S., Crossfield, I. J. M., Becker, J. C., et al. (**Pearce, L. A.**, 18 of 65) (2020) A giant planet candidate transiting a white dwarf *Nature 585*, 363

- Nielsen, L. D., Brahm, R., Bouchy, F., Espinoza, N., Turner, O., et al. (**Pearce, L. A.**, 7 of 77) (2020) Three short-period Jupiters from TESS. HIP 65Ab, TOI-157b, and TOI-169b *Astronomy and Astrophysics 639*, A76

- Blunt, S., Wang, J. J., Angelo, I., Ngo, H., Cody, D., et al. (**Pearce, L. A.**, 11 of 13) (2020) orbitize!: A Comprehensive Orbit-fitting Software Package for the High-contrast Imaging Community *The Astronomical Journal 159*, 89

- Cook, J. C., Dalle Ore, C. M., Protopapa, S., Binzel, R. P., Cruikshank, D. P., et al. (**Pearce, L. A.**, 26 of 28) (2019) The distribution of H_2O, CH_3OH, and hydrocarbon-ices on Pluto: Analysis of New Horizons spectral images *Icarus 331*, 148

- Mayo, A. W., Rajpaul, V. M., Buchhave, L. A., Dressing, C. D., Mortier, A., et al. (**Pearce, L. A.**, 23 of 30) (2019) An 11 Earth-mass, Long-period Sub-Neptune Orbiting a Sun-like Star *The Astronomical Journal 158*, 165

- Gaidos, E., Jacobs, T., LaCourse, D., Vanderburg, A., Rappaport, S., et al. (**Pearce, L.**, 7 of 16) (2019) Planetesimals around stars with TESS (PAST) - I. Transient dimming of a binary solar analogue at the end of the planet accretion era *Monthly Notices of the Royal Astronomical Society 488*, 4465
- Vanderburg, A., Huang, C. X., Rodriguez, J. E., Becker, J. C., Ricker, G. R., et al. (**Pearce, L. A.**, 36 of 51) (2019) TESS Spots a Compact System of Super-Earths around the Naked-eye Star HR 858 *The Astrophysical Journal 881*, L19

PRESENTATIONS (SELECTED)

INVITED TALKS

- Invited speaker, IFA Exoplanets Lunch Seminar Univ of Hawai'i, Sep 2023
- Invited speaker, Exoplanets Seminar Univ of Cali. Berkeley, Jun 2023
- Invited speaker, Lab for Adaptive Optics Seminar Univ of Cali. Santa Cruz, Jun 2023
- Invited speaker, APS Lunch Seminar Univ of Colorado, Oct 2022
- Invited speaker, Gemini Observatory North, Hilo HI, Feb 2019

CONTRIBUTED TALKS

- Other Worlds Laboratory, Santa Cruz CA, July 2023
- Bay Area Exoplanets Meeting, Mountain View CA, April 2023
- Alien Earths All Hands Meeting, Tucson AZ, 2023
- Steward Observatory Internal Symposium, Nov 2022

OUTREACH TALKS

- Student Veterans of America National Convention, Orlando FL, 2022
- Astronomy on Tap Tucson, Dec 2021. Link: https://www.youtube.com/watch?v=y-04uo6zsGE
- Astronomy on Tap ATX, May 2019. Link: https://www.youtube.com/watch?v=KAZRro0Qd7Y&t=291s
- Univ of Texas Astronomy Board of Visitors Winter Meeting, Feb 2019

POSTERS

- GMT Science Meeting, Washington DC, 2023
- Astrobiology Graduate Student Conference, San Diego, 2023
- Spirit of Lyot 2022, Leiden Netherlands, 2022
- AAS Division of Dynamical Astronomy, virtual, 2021
- Exoplanets III, virtual, 2020
- 233rd American Astronomical Society Meeting, Seattle, WA, 2019

WORKSHOPS

- Various, Diana Davis Spencer Scholars, Warrior Scholar Project, 2022-2023
- Research Project Leader, Warrior Scholar Project, 24 July - 29 July 2022
- PhD and Grad School Basics, SVRN (virtual), June 2022
- Resume/CV Workshop, UA VETS Center, Jan 2022
- Graduate School Application, UA VETS Center, Fall 2021
- Research Project Leader, Warrior Scholar Project, 25 July - 30 July 2021
- Research Project Leader, Warrior Scholar Project, 21 June - 26 June 2020

OBSERVING TIME AWARDED

As PI

- MagAO-X 2022B: 18 hours
- MagAO-X 2022A: 6 hours
- Gemini/NIFS: 2 hours

AWARDS AND FELLOWSHIPS

GRADUATE

2023	NSF GRFP INTERN Supplemental Funding	to NASA Ames, April-Sept 2023
2021	Travel Grant	UArizona Graduate and Professional Student Council
2019	Graduate Research Fellowship	National Science Foundation

UNDERGRADUATE

2019	Dean's Honored Graduate	Univ of Texas College of Natural Sciences
2019	George Mitchell Award	Univ of Texas Co-op
2019	Ralph Cutler Green Endowed Scholarship	Univ of Texas Astronomy/ McDonald Observatory Board of Visitors
2018	Astronaut Scholar	Astronaut Scholarship Foundation
2018	Barry Goldwater Scholar	Barry Goldwater Scholarship and Excellence in Education Foundation
2018	Jean Perkins Foundation Scholarship	Jean Perkins Foundation Grant for Undergraduate Combat Veterans
2017	Karl G. Henize Endowed Scholarship	Univ. of Texas at Austin Astronomy Department Award
2017	Chambliss Prize Honorable Mention	230th American Astronomical Society Meeting
2017	J. W. Cox Endowed Scholarship	J. W. Cox Endowment for the Advanced Studies in Astronomy
2017	Award for Excellence in Astronomy and Astrophysics Research	College of Natural Science Undergraduate Research Forum, University of Texas at Austin
2017	Jean Perkins Foundation Scholarship	Jean Perkins Foundation Grant for Undergraduate Combat Veterans
2016	Best Presentation	Fall Undergraduate Research Symposium, Univ. Texas
2016	Honorable Mention	Gulf Coast UG Research Symposium, Rice Univ.
2016	Jean Perkins Foundation Scholarship	Jean Perkins Foundation Grant for Undergraduate Combat Veterans
2015	W. Dawson Sterling Endowed Fellowship	Univ of Texas Board of Regents Award

OTHER

2009	Teacher of Promise	Kealing MS, Austin TX
2008	US Navy Commendation Medal	USS John C. Stennis (CVN-74)

BROADER IMPACTS

2022-2023	Mentor & Consultant	Diana Davis Spencer Scholars/ Warrior Scholar Project
2021-	Founder	Student Veterans Research Network
2020-2022	Research Project Leader	Warrior Scholar Project
2020-2021	Liaison	Steward Observatory DEI Mentoring Task Force
2019-	Co-host/ organizer	SpaceDrafts (Astronomy on Tap Tucson)
2016-2019	Graphics and Merchandise	Astronomy on Tap ATX
2016-2019	UG Representative	University of Texas Astronomy Department
2016-2017	Co-author	White paper for UT Astro Dept external review
2017	Co-founder	Undergraduate Astronomy Journal Club
2018	Peer mentor	Student Veteran Association

REFERENCES

Dr. Jared Males	Steward Observatory, Univ of Arizona (jrmales@email.arizona.edu)
Dr. Natasha Batalha	NASA Ames (natasha.e.batalha@nasa.gov)
Dr. Alycia Weinberger	Carnegie EPL (aweinberger@carnegiescience.edu)
Dr. Adam Kraus	University of Texas at Austin (alk@astro.as.utexas.edu)

NSF AAPF

Project Summary

Overview:

White dwarf stars (WDs) are incredible laboratories for exoplanet science. Their strong gravities cause elements to stratify leaving pure hydrogen and/or helium photospheres. Any metals observed in their photosphere spectra (called pollution) must have been deposited recently from the planetary regime, providing one of the only probes of exoplanetary material refractory composition. The mechanism for deposition of material onto the WD surface is not well understood. While there is some research on influence of a wide stellar companion on the formation of exoplanets, a population study of the pollution rates of SLS will probe the influence of a wide stellar companion of the planetary regime for mature systems following the AGB phase of the host. While there is some research on influence of a wide stellar companion on the formation of exoplanets, a population study of the pollution rates of SLS will probe the influence of a wide stellar companion of the planetary regime for mature systems following the AGB phase of the host. Understanding of the dynamical influence of a wide stellar companion on the planetary regime is hampered however by low population statistics, particularly for WDs with AFGK stars (called "Sirius-Like Systems", SLS) where the WD's contribution to the spectral energy distribution is drowned out by the brighter main sequence star.

The latest generation of extreme high-contrast adaptive optics (ExAO) instruments are exceptionally well suited for this science case. Extending her previous work with the ExAO instrument MagAO-X, Logan Pearce, the proposer, has designed an extensive observational survey to detect new SLS and examine the WD for pollution called The ExAO Pup Search [1]. The Pup Search will use the ExAO instruments MagAO-X and SCExAO to detect new systems, astrometric and RV monitoring to constrain orbits, and spectroscopy from HST and Keck/HIRES to look for pollution. This program will be carried out at Steward Observatory at the University of Arizona, which provides unparalleled access to the resources required for the program, with the sponsoring scientist Dr. Olivier Guyon.

Intellectual Merit:

The data-set produced by the Pup Search will be invaluable to both the exoplanet and white dwarf communities. It will produce a new population of SLS and (un)polluted white dwarfs which will grow the sample size of these systems to enable population-level studies of pollution rates and orbital characteristics. It will provide more pollution measurements of the refractory compositions of exoplanetary material, and probe the influence of a wide stellar companion post-AGB phase. It will also provide observations for comparison to theoretical predictions of the orbital parameters for which the wide companion would be contributing to driving material onto the WD surface.

Broader Impacts:

Veterans are a statistically underrepresented group in higher education, and their retention lags peers, particularly in STEM fields. Student veterans face a unique set of challenges to completing undergraduate STEM degrees, but getting them involved in STEM research in labs and research groups can help mitigate some of these challenges. Building on the success of student veteran research programs at the University of Arizona, Pearce will produce the Student Veterans Research Symposium to showcase the science being conducted by undergrad, graduate, and post-doctoral veterans to promote community, increase visibility, promote professional development, and showcase achievements. The Symposium will begin with local area universities and grow to a national event. Pearce will work with Dr. Jared Males, NSF, and UA stakeholders to organize and fund the Symposium.

[1] The name is a reference to the first known wide White Dwarf – Main Sequence system, Sirius AB. Since Sirius A is the "Dog Star", Sirius B was nicknamed "The Pup"

PROJECT DESCRIPTION

The ExAO Pup Search:
Probing planets in wide binaries by leveraging the power of extreme adaptive optics towards White Dwarf + Main Sequence star systems

The ExAO Pup Search
The search for non-interacting white dwarf - main sequence binaries with MagAO-X and SCExAO

OBJECTIVE: **The study of the pollution and orbital characteristics of non-interacting white dwarf/main sequence star systems provides a direct probe of the influence of the wide companion on the planetary region.**

ASTRONOMICAL CONTEXT: Multiple star systems are an extremely common outcome of the star formation process, especially for higher-mass stars [14]. I am interested in the formation and dynamical evolution of planetary systems around one star in a wide binary — “S-type", as opposed to “P-type" (circumbinary) planets — under the gravitational influence of the wide stellar companion. It is becoming clear that S-type planets are not uncommon [8, 5, 6], and companions will exert gravitational influence on the planetary regime throughout the star’s lifetime impacting the formation and survival of S-type planets. **Observational tests are critical for theoretical predictions of how and to what degree companions influence planetary systems throughout the star’s lifetime.**

White Dwarf - Main Sequence polluted binaries are crucial to exoplanet research:

- *WD pollution is the only method of probing the non-volatile composition of exoplanetary material*
- *Polluted WDMS systems probe the formation and survival of exoplanetary material in wide binary systems*
- *Small population statistics currently hinder studies*
- *High-contrast imaging instruments and techniques are ideal for addressing this problem*

White dwarfs (WD) with (non-interacting) main sequence star companions (WDMS) are an excellent laboratory for probing the influence of a wide companion at late stages of planetary system evolution. Due to their extreme gravity, elements stratify on short timescales (minutes – years) leaving pure H and He photospheres. Any metals observed in the spectra of WDs, called pollution, were deposited recently from the planetary regime [29]. **WD pollution is the only method of probing the refractory compositions of exoplanetary material** [e.g. 31, 26, 33, 23]. WDs show pollution independent of cooling age [27], requiring a mechanism(s) to deposit material that is independent of age [22]. **A wide stellar companion is one such possible mechanism** [32, 22]. The role of the companion in driving material onto the WD is unknown, but may impact the planetary regime through: 1. pushing previously stable planet orbits into regions of chaotic orbits as the primary loses mass and the companion’s orbit expands [32, 11], 2. evolving onto high-eccentricity orbits through external perturbations [4, 9, 28] inducing regions of chaos [2], 3. driving von-Zeipel-Kozai-Lidov oscillations [9, 15], 4. driving secular resonances [2], 5. pushing surviving planets onto close orbits [13], 6. inducing a 2nd or 3rd generation of planet formation [21].

Many of these scenarios produce observationally testable predictions. Stephan et al. [25] determined the distribution of orbital parameters for a WD polluted by the Eccentric Kozai-Lidov (EKL) mechanism to which the orbits of a population of polluted WDMS systems can be compared. Veras et al. [28, Fig 3] made predictions of companion semi-major axis and eccentricity combinations for which the primary's planetary regime is (un)stable at various stellar evolutionary phases which can be compared to (non-)polluted WDMS system architecture.

As one star evolves off the main sequence, they can either evolve into interacting or non-interacting systems [30]; non-interacting WDMS orbits expand as primary loses mass into a regime amenable to direct imaging instrumentation. Additionally, the number of known nearby white dwarfs is fewer than expected from stellar evolution — the "missing white dwarf" problem [12, 10]. For so-called 'Sirius-Like Systems" (SLS), a multiple system containing a white dwarf with a more-luminous K-type or earlier companion(s), the white dwarf contribution to the SED is drowned out by the more luminous MS star, and can't be easily detected. **This motivates probing this population via high-contrast imaging detection methods**.

INTELLECTUAL MERIT

My plan as an NSF fellow is to execute an observational survey to leverage the power of the new extreme adaptive optics (ExAO) instruments MagAO-X and SCExAO towards detection and characterization of SLS with a survey called The ExAO Pup Search: The extreme AO non-interacting white dwarf-main sequence binary system survey[1]. The Pup Search has three main objectives:

1. Detect new non-interacting WDMS binary systems with MagAO-X and SCExAO and observe new systems for pollution with VIS-X, HST, and Keck/HIRES
2. Monitor orbits of new and previously known resolved WDMS systems with imaging and radial velocity to determine prevalence of high-eccentricity orbits of MS companions for polluted WDs and compare to estimated orbital parameters for the binary to be influencing pollution, such as those in Stephan et al. 25 and Veras et al. 28 Fig 3.
3. Determine pollution rates for WDMS systems with VIS-X, HST, and Keck/HIRES, compare to single WDs and as a function of cooling age, and compare to estimates such as Veras et al. [29]

There is a demonstrated need in both exoplanet and WD communities for a dataset of this kind. We will grow the sample size of non-interacting white dwarf-main sequence binaries and produce observational tests of the role of wide companions on the planetary regime; as a byproduct we will also be contributing to the missing WD problem by identifying new WDMS systems in the local region and testing the wide companion influence on pollution. This proposed research addresses several gaps identified in the NASA/JPL Exoplanet Exploration Program Science Gap List (Stapelfeld & Mamajek, 2023, JPL Document No: 1792073-2) including SCI-14: Exoplanet interior structure and material properties and SCI-04: Planetary system architectures and occurrence rates.

We observed 5 Pup Search systems with MagAO-X in 2022 and detected at least one new WD companion (Figure 1), which demonstrates the effectiveness of this survey. Zuckerman [32] compiled 38 polluted WDMS and found that the companion suppresses the formation and/or long term stability of planets; they acknowledge that these are small-number statistics and call for further observational surveys with this goal in mind. It is possible that polluted WDMS may be rare, however a larger population size is required, which this survey will provide. It will also be challenging to detect pollution lines with VIS-X as optical metal lines are typically rare and weak; spectra in the 0.3-0.4 μm range with HST and Keck/HIRES is optimal for line detection. The smaller mirror of HST is not a challenge to spatial resolution moving to UV wavelengths as for both HST at 0.3μm and MagAO-X at 0.8μm, $1\lambda/D \approx 25$ mas, so new systems detected by MagAO-X should be accessible to HST in UV.

[1] The name is a reference to the first known wide White Dwarf- Main Sequence system, Sirius AB discovered in 1844 by Friedrich Bessel when he observed changes in the proper motion of Sirius [3], first observed by Alvin Graham Clark [7], and confirmed as the second ever known WD via its spectrum obtained by Walter Adams [1]. Since Sirius A is the "Dog Star", Sirius B was nicknamed "The Pup"

The Keck/HIRES instrument offers high-resolution spectra from 0.3-0.9 μm, offering a broad spectral range covering multiple regimes with pollution lines. Additionally, orbital periods for SLS can be long making orbital parameter determination difficult. Non-interacting orbital periods from 3−300,000 years are common [30]. The Pup Search is targeting objects close to the inner working angle of nearby stars, where periods are shorter and radial velocity will yield better orbit constraints. Astrometric and RV measurements made during this fellowship will contribute to long-term orbit monitoring of these systems for future orbit constraints beyond the fellowship period.

Applicant Qualification. As a member of the MagAO-X team during my PhD I have had 24 hours MagAO-X observing time as PI awarded over 2 semesters, 18 of which were for preliminary Pup Search observations. The remaining 6 hours resulted in publication of a new binary system HIP 67506 AC [20]. I have extensive experience with long-period orbit monitoring [16, 17, 18] and with high-contrast image processing and data analysis [19, 20].

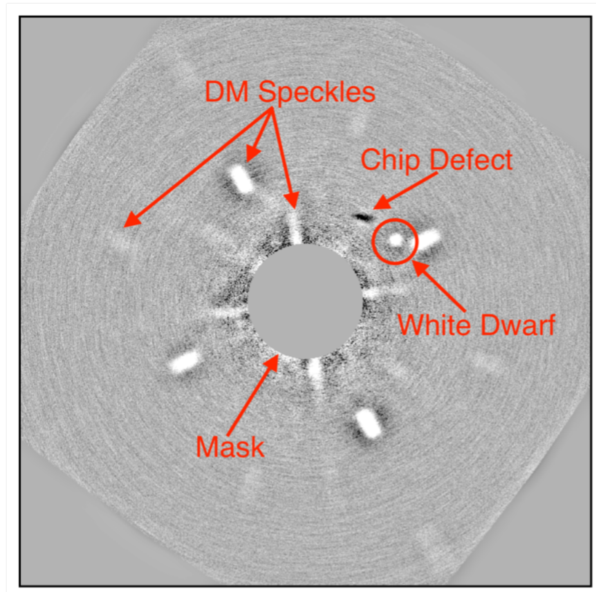


Figure 1: *A new WD companion (red circle) to a main sequence star discovered in i' band with MagAO-X in 2022 as part of the Pup Search program. Host star PSF was removed by unsharp mask and radial profile subtraction; mask, chip defect, and speckles caused by the deformable mirror are labeled. The new WD companion is indicated by the red circle.*

Timeline

Figure 2 displays a plan for the organization of this project. In year one my focus will be on detecting previously unknown WDMS systems with MagAO-X and SCExAO (Objective 1). As this process has already begun during my PhD, I already have a robust target list of MS stars highly likely to contain a hidden WD as selected by UV excess in Ren et al. [24], from which I have discovered at least one new WDMS (Figure 2). I will also compile a target list for orbit monitoring of known SLS and begin observations with other telescope resources (Objective 2). I expect publication of new WDMS detections at the end of year one. In year two I will continue Objective 1 and 2 observations and begin to shift focus to Objective 3 by applying for HST, Keck, and VIS-X time, with a second publication of new detections and preliminary orbit monitoring results expected near the end of year two. In year three my focus will primarily be on HST, Keck, and VIS-X spectroscopic observations, with publication of (un)polluted WDs and pollution rates expected near the end of year three.

Risk mitigation

This ambitious survey relies on the availability of primarily ground-based instruments, MagAO-X, SCExAO, and Keck, which are subject to observing and maintenance schedules, travel restrictions, and weather. MagAO-X's observing schedule was significantly impacted by COVID and related travel restrictions, and our 2022A observing run was hampered by weather, both of which would impact Objective 1. I will mitigate this risk by applying for time over multiple observing seasons on all instruments/telescopes. Objective 2 can be supplemented with other telescope resources, and HST observations of Objective 3 are not impacted by ground-based restrictions. Objective 3 relies on the availability of HST and Keck spectroscopy, with the main risk being continued availability of HST and

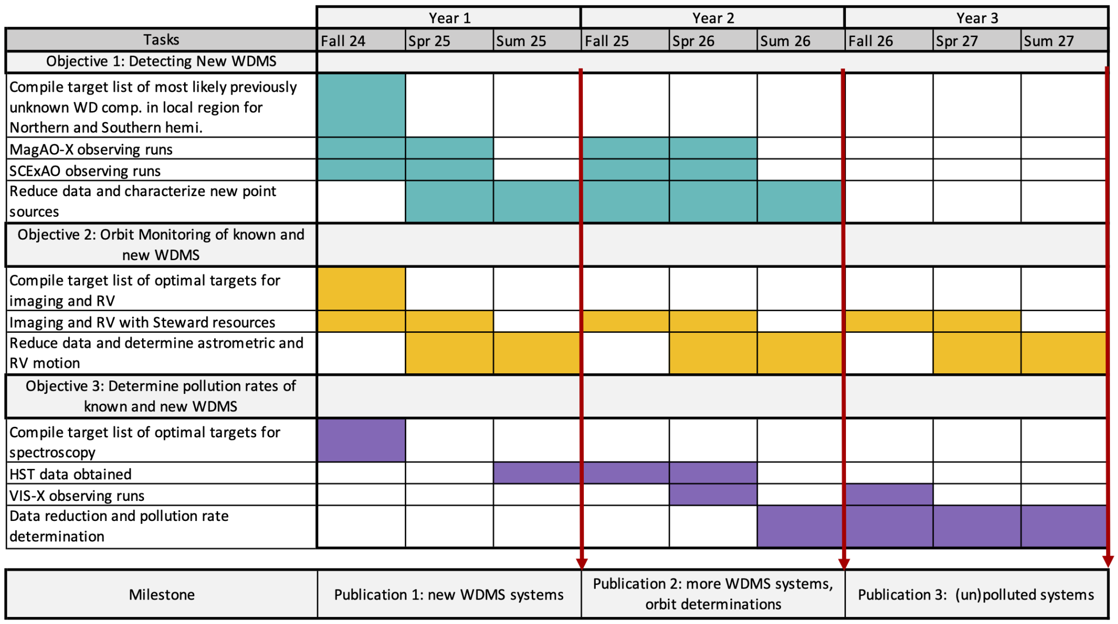


Figure 2: *Project plan and timeline*

being awarded HST and Keck observing hours for this program.

Outcomes

Short term outcomes of the fellowship include providing the **exoplanet community** with a robust investigation of S-type planets in binaries at the end of the star's lifetime, with new WD pollution data providing more evidence of refractory compositions of exoplanets, and providing the **white dwarf community** with an expanded population of SLS. These data produced by this fellowship will be invaluable to both fields. This program builds upon all the strengths developed during my PhD while also pushing me into the new regimes of UV spectroscopy, radial velocity observations, and space-based observations. It enables me to build new professional relationships within the exoplanet community as well as forge new collaborations in the polluted white dwarf community.

Broader Impacts

When I separated from the US Navy in 2008 after a 5 year career as an officer, I found it much more difficult to transition to civilian life than I had expected, both socially and professionally. I struggled to translate my experiences into a civilian-friendly resume, and to find a group of people who understood where I was coming from. When I decided to return to university for a bachelors degree in astronomy and physics in 2015, I connected with the Student Veterans Association at the University of Texas (UT), and found the kind of personally and professionally supportive community I wish I had had 7 years earlier.

Veterans are a statistically underrepresented group in higher education despite the numerous education benefits accompanying veteran status. Veterans are 7% of the US population over 18, yet they make up 3.7% of undergraduate students at the University of Arizona (UA), and 3.6% of STEM majors. At UA, veteran retention also lags compared to all students, with 31% of veteran STEM majors graduating after 6 years compared to 63% of all undergraduates[2]. The veteran population disproportionately comes from other underrepresented groups as well, such as racial minorities and first-generation col-

[2]Source: UA Analytics as of 2020

lege students. Veterans are significantly more likely to have dependents, military reserve obligations, and specific requirements related to education benefits (e.g. needing to take a full course load in order to receive a housing stipend), all of which can limit access to the kinds of opportunities that make graduate school applications stand out.

Veterans often don't realize how their military experience can be applied to STEM academics and careers. In addition to technical skills, veterans tend to underestimate the "soft skills" they've attained in the service, such as leadership and management, and how they can be leveraged for academic and research success. Many student veterans I've known were nervous about how their age and life experience makes them different from their college peers, something which actually is a major strength.

	Year 1			Year 2			Year 3		
	Fall 24	Spr 25	Sum 25	Fall 25	Spr 26	Sum 26	Fall 26	Spr 27	Sum 27
Local symposium for host institution and local community colleges		X							
Regional symposium including school from neighboring states					X				
National symposium								X	

Figure 3: *Symposium timeline*

Getting STEM-inclined veterans involved in STEM research in undergrad can increase retention by (1) helping them see past barriers such as difficult classes, (2) fostering community in academia by becoming contributing members of a research group, mitigating perceptions of otherness due to age and life-stage differences with peers, (3) fostering a sense of purpose by contributing meaningfully to active research, and (4) utilizing skills from service in a new way or uncovering new skills.

It's for these reasons that I have been motivated to help my student veteran peers make the most of the opportunities available in undergraduate and graduate programs. As a PhD student at the University of Arizona I worked for three summers as a Research Project Leader for the Warrior Scholar Program (WSP), conducting week-long projects introducing scientific research and coding as part of WSP's two week "boot camp" for veterans transitioning into undergraduate programs. I worked for an academic year as a consultant for WSP's Diana Davis Spencer Scholars program in which I gave workshops, shared resources, and gave application material feedback for a cohort of 25 WSP alumni who were applying for graduate school. I intend to continue serving my veteran community as a postdoctoral researcher at the University of Arizona.

Budget	
Keynote speaker travel and accomodation	$1,000
Coffee, lunch, snacks throughout day	$1,000
Conference dinner/reception	$2,000
Total	$4,000

Figure 4: *Example Symposium budget for the first local Symposium.*

Building on the success of research conferences aimed at diversity and specific student groups, such as The Conference for Undergradute Women in Phyiscs (CUWiP) and the Society for Advancement of Chicanos/Hispanics & Native Americans in Science conference (SACNAS), **I propose to start the annual Veterans Research Symposium** at UA, a student veteran focused scientific research conference showcasing the research produced by veterans across disciplines at undergraduate, graduate, and post-doc levels. Together with my PhD advisor, Dr. Jared Males (also a US Navy veteran), we have already begun the work of refining this idea and taking the first steps at the University of Arizona. The goal of the conference is to **promote community** among student veterans across disciplines, **increase visibility** of veteran researchers and encourage recruitment into research, **enable connection** for graduate programs looking to recruit student veterans, and **showcase the skills and achievements of veterans in STEM** research to encourage recruitment and retention of veterans. Taking place over two days, the conference will consist of multiple poster and/or talk sessions, workshops, and a keynote speaker. We plan to begin with local area universities initially, building eventually to a national conference. Figure 1 displays a proposed timeline; Figure 2 displays an example budget for the first local

Symposium. I anticipate spending approximately 10% of my time on developing the conference, ramping up to 25% as the conference approaches. We will work closely with UA and NSF to fund the initial Symposium, and build on its success to expand funding for the larger events. We will track participation rates by veteran researchers, as well as attendance by non-veterans to assess the utility of this symposium. **The support of this fellowship at UA will enable me to continue this work and see the Symposium through to success.**

JUSTIFICATION OF HOST INSTITUTION

Host Institution: University of Arizona
Faculty Mentor: Olivier Guyon
The University of Arizona's Steward Observatory (hereafter UA) is the ideal institution to host the survey I am proposing. MagAO-X on the Magellan Clay Telescope, of which UA is a partner, is especially well suited to this science. It is built for extreme high contrast imaging on the order of 10^{-7}, so the contrasts involved in Sirius-Like Systems (SLS) [$\mathcal{O}(10^{-2}-10^{-4})$] are easily achieved in short observation times. MagAO-X is optimized for optical wavelengths where WDMS star contrasts are much lower and inner working angles are smaller compared to IR-optimized high-contrast instruments. MagAO-X achieves exceedingly high Strehl ratio ($\sim$ 70% in z′) in optical wavelengths compared to other adaptive optics instruments. We also plan to use its high-resolution spectrograph, VIS-X, for spatially resolved spectra. While optical pollution features in white dwarfs are less common and harder to detect than UV, VIS-X will complement our planned UV HST and Keck/HIRES spectra (Objective 3). As a current member of the MagAO-X team I have already begun initial Pup Search observations with new white dwarf companion discoveries. Steward Observatory additionally offers a wealth of telescope resources for Pup Search Objective 2 - orbit monitoring of SLS. In addition to the astrometry provided by MagAO-X, Steward offers access to several radial velocity instruments including the MIKE spectrograph at Magellan, NEID, and the Habitable Planet Finder (HPF) to complement the astrometry and provide better orbit constraints. Astrometry can also be supplemented with additional Steward resources like MMT/MAPS and LBT/SHARK-NIR or SHARK-VIS.

Due to the joint appointment of Olivier Guyon to Steward and NAOJ, hosting my fellowship at Arizona offers access to SCExAO, the extreme AO instrument on Subaru Telescope of which Olivier is the PI. This opens up the Pup Search survey to both northern and southern hemisphere targets. SCExAO/VAMPIRES offers a newly-commissioned four color imaging mode which enables fast color characterization of candidates to vet white dwarf status.

In addition to the expertise that Dr. Jared Males (MagAO-X PI) and Dr. Olivier Guyon (SCExAO PI) will lend to the success of this survey, there are a number of other faculty at Arizona that can provide additional support. Dr. Chad Bender (NEID PI and HPF team member) will be invaluable for the RV objective of this survey, as students and post-docs in Daniel Apai's and other exoplanet groups in Steward and Lunar Planetary Laboratory also on UA campus.

Additionally, while a grad student I have done work contributing to the science goals of GMagAO-X, the ExAO instrument our group is building for the GMT. GMT/GMagAO-X will be invaluable tools for WDMS characterization, in addition to detection and characterization of hundreds of exoplanets in reflected light. I am excited by the mission of GMagAO-X, and hosting my fellowship at Arizona will allow me to continue to collaborate on this vital instrument for the future of exoplanet direct imaging.

Finally, hosting my fellowship at Arizona is ideal for my diversity, equity, and inclusion efforts. Below, in my Broader Impacts section, I detail a proposal for a veteran-specific research symposium. Dr. Jared Males and I have begun the work of initiating this symposium at UA, including formulating a plan and beginning discussions with relevant University parties. This is an effort I care deeply about seeing through, and hosting my fellowship at UA will allow me to continue to build on work already begun.

After serving 5 years on active duty in the Navy and teaching 6 years in middle school, I have learned what it takes to thrive in my professional life. Given my previous professional experiences, and my already well established world-wide collaborator network, continuing my research program by hosting my fellowship at UA is the best match for me both personally and professionally.

Long Term Career Goals

I intend to pursue a career in astronomical research in exoplanet direct imaging. I will pursue research scientist positions at observatories, research facilities, or universities, however I will also consider faculty positions. As an NSF fellow at the University of Arizona, I will pursue my proposed and related research as well as continue my service to the student veteran community. In my postdoctoral career and beyond I will strive to meaningfully contribute to the exoplanet and white dwarf communities and provide a welcoming and supportive community for student veterans and non-traditional students.

References

[1] W. S. Adams. The Spectrum of the Companion of Sirius. , 27(161):236, Dec. 1915. doi: 10.1086/122440.

[2] Á. Bazsó and E. Pilat-Lohinger. Fear the Shadows of the Giants: On Secular Perturbations in Circumstellar Habitable Zones of Double Stars. *Astronom. J.*, 160(1):2, July 2020. doi: 10.3847/1538-3881/ab9104.

[3] F. W. Bessel. On the variations of the proper motions of Procyon and Sirius. *Mon. Not. R. Astron. Soc.*, 6:136–141, Dec. 1844. doi: 10.1093/mnras/6.11.136.

[4] A. Bonsor and D. Veras. A wide binary trigger for white dwarf pollution. *Mon. Not. R. Astron. Soc.*, 454:53–63, Nov. 2015. ISSN 0035-8711. doi: 10.1093/mnras/stv1913.

[5] S. Christian, A. Vanderburg, J. Becker, D. A. Yahalomi, L. Pearce, G. Zhou, K. A. Collins, A. L. Kraus, K. G. Stassun, Z. de Beurs, G. R. Ricker, R. K. Vanderspek, D. W. Latham, J. N. Winn, S. Seager, J. M. Jenkins, L. Abe, K. Agabi, P. J. Amado, D. Baker, K. Barkaoui, Z. Benkhaldoun, P. Benni, J. Berberian, P. Berlind, A. Bieryla, E. Esparza-Borges, M. Bowen, P. Brown, L. A. Buchhave, C. J. Burke, M. Buttu, C. Cadieux, D. A. Caldwell, D. Charbonneau, N. Chazov, S. Chimaladinne, K. I. Collins, D. Combs, D. M. Conti, N. Crouzet, J. P. de Leon, S. Deljookorani, B. Diamond, R. Doyon, D. Dragomir, G. Dransfield, Z. Essack, P. Evans, A. Fukui, T. Gan, G. A. Esquerdo, M. Gillon, E. Girardin, P. Guerra, T. Guillot, E. K. K. Habich, A. Henriksen, N. Hoch, K. I. Isogai, E. Jehin, E. L. N. Jensen, M. C. Johnson, J. H. Livingston, J. F. Kielkopf, K. Kim, K. Kawauchi, V. Krushinsky, V. Kunzle, D. Laloum, D. Leger, P. Lewin, F. Mallia, B. Massey, M. Mori, K. K. McLeod, D. Mékarnia, I. Mireles, N. Mishevskiy, M. Tamura, F. Murgas, N. Narita, R. Naves, P. Nelson, H. P. Osborn, E. Palle, H. Parviainen, P. Plavchan, F. J. Pozuelos, M. Rabus, H. M. Relles, C. Rodríguez López, S. N. Quinn, F.-X. Schmider, J. E. Schlieder, R. P. Schwarz, A. Shporer, L. Sibbald, G. Srdoc, C. Stibbards, H. Stickler, O. Suarez, C. Stockdale, T.-G. Tan, Y. Terada, A. Triaud, R. Tronsgaard, W. C. Waalkes, G. Wang, N. Watanabe, M.-S. Wenceslas, G. Wingham, J. Wittrock, and C. Ziegler. A Possible Alignment Between the Orbits of Planetary Systems and their Visual Binary Companions. *Astronom. J.*, 163(5):207, May 2022. doi: 10.3847/1538-3881/ac517f.

[6] A. Eggenberger, S. Udry, and M. Mayor. Statistical properties of exoplanets. III. Planet properties and stellar multiplicity. *Astronomy & Astrophysics*, 417:353–360, Apr. 2004. doi: 10.1051/0004-6361:20034164.

[7] C. Flammarion. The Companion of Sirius. *Astronomical register*, 15:186–189, Jan. 1877.

[8] C. Fontanive and D. Bardalez Gagliuffi. The Census of Exoplanets in Visual Binaries: population trends from a volume-limited Gaia DR2 and literature search. *Frontiers in Astronomy and Space Sciences*, 8:16, Mar. 2021. doi: 10.3389/fspas.2021.625250.

[9] A. S. Hamers and S. F. Portegies Zwart. White dwarf pollution by planets in stellar binaries. *Mon. Not. R. Astron. Soc.*, 462:L84–L87, Oct. 2016. ISSN 0035-8711. doi: 10.1093/mnrasl/slw134.

[10] J. B. Holberg, T. D. Oswalt, E. M. Sion, M. A. Barstow, and M. R. Burleigh. Where are all the Sirius-like binary systems? *Mon. Not. R. Astron. Soc.*, 435(3):2077–2091, Nov. 2013. doi: 10.1093/mnras/stt1433.

[11] N. A. Kaib, S. N. Raymond, and M. Duncan. Planetary system disruption by Galactic perturbations to wide binary stars. *Nat.*, 493(7432):381–384, Jan. 2013. doi: 10.1038/nature11780.

[12] B. Katz, S. Dong, and D. Kushnir. Luminosity function suggests up to 100 white dwarfs within 20 pc may be hiding in multiple systems. *arXiv e-prints*, art. arXiv:1402.7083, Feb. 2014. doi: 10.48550/arXiv.1402.7083.

[13] K. M. Kratter and H. B. Perets. Star Hoppers: Planet Instability and Capture in Evolving Binary Systems. *Astrophys. J.*, 753(1):91, July 2012. doi: 10.1088/0004-637X/753/1/91.

[14] M. Moe and R. Di Stefano. Mind Your Ps and Qs: The Interrelation between Period (P) and Mass-ratio (Q) Distributions of Binary Stars. *Astrophys J., Sup.*, 230(2):15, June 2017. doi: 10.3847/1538-4365/aa6fb6.

[15] A. J. Mustill, M. B. Davies, S. Blunt, and A. Howard. Dynamical orbital evolution scenarios of the wide-orbit eccentric planet HR 5183b. *Mon. Not. R. Astron. Soc.*, 509(3):3616–3625, Jan. 2022. doi: 10.1093/mnras/stab3174.

[16] L. A. Pearce, A. L. Kraus, T. J. Dupuy, M. J. Ireland, A. C. Rizzuto, B. P. Bowler, E. K. Birchall, and A. L. Wallace. Orbital Motion of the Wide Planetary-mass Companion GSC 6214-210 b: No Evidence for Dynamical Scattering. *Astronom. J.*, 157(2):71, Feb. 2019. doi: 10.3847/1538-3881/aafacb.

[17] L. A. Pearce, A. L. Kraus, T. J. Dupuy, A. W. Mann, E. R. Newton, B. M. Tofflemire, and A. Vanderburg. Orbital Parameter Determination for Wide Stellar Binary Systems in the Age of Gaia. *Astrophys. J.*, 894(2):115, May 2020. doi: 10.3847/1538-4357/ab8389.

[18] L. A. Pearce, A. L. Kraus, T. J. Dupuy, A. W. Mann, and D. Huber. Boyajian's Star B: The Co-moving Companion to KIC 8462852 A. *Astrophys. J.*, 909(2):216, Mar. 2021. doi: 10.3847/1538-4357/abdd33.

[19] L. A. Pearce, J. R. Males, A. J. Weinberger, J. D. Long, K. M. Morzinski, L. M. Close, and P. M. Hinz. Companion mass limits for 17 binary systems obtained with binary differential imaging and MagAO/Clio. *Mon. Not. R. Astron. Soc.*, 515(3):4487–4504, Sept. 2022. doi: 10.1093/mnras/stac2056.

[20] L. A. Pearce, J. R. Males, S. Y. Haffert, L. M. Close, J. D. Long, A. L. McLeod, J. M. Knight, A. D. Hedglen, A. J. Weinberger, O. Guyon, M. Kautz, K. Van Gorkom, J. Lumbres, L. Schatz, A. Rodack, V. Gasho, J. Kueny, W. Foster, K. M. Morzinski, and P. M. Hinz. HIP 67506 C: MagAO-X confirmation of a new low-mass stellar companion to HIP 67506 A. *Mon. Not. R. Astron. Soc.*, 521(3):4775–4784, May 2023. doi: 10.1093/mnras/stad859.

[21] H. B. Perets. Planets in Evolved Binary Systems. In S. Schuh, H. Drechsel, and U. Heber, editors, *Planetary Systems Beyond the Main Sequence*, volume 1331 of *American Institute of Physics Conference Series*, pages 56–75, Mar. 2011. doi: 10.1063/1.3556185.

[22] C. Petrovich and D. J. Muñoz. Planetary Engulfment as a Trigger for White Dwarf Pollution. *Astrophys. J.*, 834:116, Jan. 2017. ISSN 0004-637X. doi: 10.3847/1538-4357/834/2/116.

[23] K. D. Putirka and S. Xu. Polluted white dwarfs reveal exotic mantle rock types on exoplanets in our solar neighborhood. *Nat. Commun.*, 12:6168, Nov. 2021. ISSN 2041-1723. doi: 10.1038/s41467-021-26403-8.

[24] J. J. Ren, R. Raddi, A. Rebassa-Mansergas, M. S. Hernandez, S. G. Parsons, P. Irawati, P. Rittipruk, M. R. Schreiber, B. T. Gänsicke, S. Torres, H. J. Wang, J. B. Zhang, Y. Zhao, Y. T. Zhou, Z. W. Han, B. Wang, C. Liu, X. W. Liu, Y. Wang, J. Zheng, J. F. Wang, F. Zhao, K. M. Cui, J. R. Shi, and H. Tian. The White Dwarf Binary Pathways Survey. V. The Gaia White Dwarf Plus AFGK Binary Sample and the Identification of 23 Close Binaries. *Astrophys. J.*, 905(1):38, Dec. 2020. doi: 10.3847/1538-4357/abc017.

[25] A. P. Stephan, S. Naoz, and B. Zuckerman. Throwing Icebergs at White Dwarfs. *Astrophys. J. Let.*, 844(2):L16, Aug. 2017. doi: 10.3847/2041-8213/aa7cf3.

[26] D. Veras. Post-main-sequence planetary system evolution. *Royal Society Open Science*, 3:150571, Feb. 2016. doi: 10.1098/rsos.150571.

[27] D. Veras, A. J. Mustill, B. T. Gänsicke, S. Redfield, N. Georgakarakos, A. B. Bowler, and M. J. S. Lloyd. Full-lifetime simulations of multiple unequal-mass planets across all phases of stellar evolution. *Mon. Not. R. Astron. Soc.*, 458(4):3942–3967, June 2016. doi: 10.1093/mnras/stw476.

[28] D. Veras, N. Georgakarakos, I. Dobbs-Dixon, and B. T. Gänsicke. Binary star influence on post-main-sequence multi-planet stability. *Mon. Not. R. Astron. Soc.*, 465:2053–2059, Feb. 2017. ISSN 0035-8711. doi: 10.1093/mnras/stw2699.

[29] D. Veras, S. Xu, and A. Rebassa-Mansergas. The critical binary star separation for a planetary system origin of white dwarf pollution. *Mon. Not. R. Astron. Soc.*, 473:2871–2880, Jan. 2018. ISSN 0035-8711. doi: 10.1093/mnras/stx2141.

[30] B. Willems and U. Kolb. Detached white dwarf main-sequence star binaries. *Astronomy & Astrophysics*, 419:1057–1076, June 2004. doi: 10.1051/0004-6361:20040085.

[31] S. Xu and A. Bonsor. Exogeology from Polluted White Dwarfs. *Elements*, 17(4):241, Aug. 2021. doi: 10.48550/arXiv.2108.08384.

[32] B. Zuckerman. The Occurrence of Wide-orbit Planets in Binary Star Systems. *Astrophys. J.*, 791: L27, Aug. 2014. ISSN 0004-637X. doi: 10.1088/2041-8205/791/2/L27.

[33] B. Zuckerman, D. Koester, C. Melis, B. M. Hansen, and M. Jura. The Chemical Composition of an Extrasolar Minor Planet. *Astrophys. J.*, 671(1):872–877, Dec. 2007. doi: 10.1086/522223.

References

[1] W. S. Adams. The Spectrum of the Companion of Sirius. , 27(161):236, Dec. 1915. doi: 10.1086/122440.

[2] Á. Bazsó and E. Pilat-Lohinger. Fear the Shadows of the Giants: On Secular Perturbations in Circumstellar Habitable Zones of Double Stars. *Astronom. J.*, 160(1):2, July 2020. doi: 10.3847/1538-3881/ab9104.

[3] F. W. Bessel. On the variations of the proper motions of Procyon and Sirius. *Mon. Not. R. Astron. Soc.*, 6:136–141, Dec. 1844. doi: 10.1093/mnras/6.11.136.

[4] A. Bonsor and D. Veras. A wide binary trigger for white dwarf pollution. *Mon. Not. R. Astron. Soc.*, 454:53–63, Nov. 2015. ISSN 0035-8711. doi: 10.1093/mnras/stv1913.

[5] S. Christian, A. Vanderburg, J. Becker, D. A. Yahalomi, L. Pearce, G. Zhou, K. A. Collins, A. L. Kraus, K. G. Stassun, Z. de Beurs, G. R. Ricker, R. K. Vanderspek, D. W. Latham, J. N. Winn, S. Seager, J. M. Jenkins, L. Abe, K. Agabi, P. J. Amado, D. Baker, K. Barkaoui, Z. Benkhaldoun, P. Benni, J. Berberian, P. Berlind, A. Bieryla, E. Esparza-Borges, M. Bowen, P. Brown, L. A. Buchhave, C. J. Burke, M. Buttu, C. Cadieux, D. A. Caldwell, D. Charbonneau, N. Chazov, S. Chimaladinne, K. I. Collins, D. Combs, D. M. Conti, N. Crouzet, J. P. de Leon, S. Deljookorani, B. Diamond, R. Doyon, D. Dragomir, G. Dransfield, Z. Essack, P. Evans, A. Fukui, T. Gan, G. A. Esquerdo, M. Gillon, E. Girardin, P. Guerra, T. Guillot, E. K. K. Habich, A. Henriksen, N. Hoch, K. I. Isogai, E. Jehin, E. L. N. Jensen, M. C. Johnson, J. H. Livingston, J. F. Kielkopf, K. Kim, K. Kawauchi, V. Krushinsky, V. Kunzle, D. Laloum, D. Leger, P. Lewin, F. Mallia, B. Massey, M. Mori, K. K. McLeod, D. Mékarnia, I. Mireles, N. Mishevskiy, M. Tamura, F. Murgas, N. Narita, R. Naves, P. Nelson, H. P. Osborn, E. Palle, H. Parviainen, P. Plavchan, F. J. Pozuelos, M. Rabus, H. M. Relles, C. Rodríguez López, S. N. Quinn, F.-X. Schmider, J. E. Schlieder, R. P. Schwarz, A. Shporer, L. Sibbald, G. Srdoc, C. Stibbards, H. Stickler, O. Suarez, C. Stockdale, T.-G. Tan, Y. Terada, A. Triaud, R. Tronsgaard, W. C. Waalkes, G. Wang, N. Watanabe, M.-S. Wenceslas, G. Wingham, J. Wittrock, and C. Ziegler. A Possible Alignment Between the Orbits of Planetary Systems and their Visual Binary Companions. *Astronom. J.*, 163(5):207, May 2022. doi: 10.3847/1538-3881/ac517f.

[6] A. Eggenberger, S. Udry, and M. Mayor. Statistical properties of exoplanets. III. Planet properties and stellar multiplicity. *Astronomy & Astrophysics*, 417:353–360, Apr. 2004. doi: 10.1051/0004-6361:20034164.

[7] C. Flammarion. The Companion of Sirius. *Astronomical register*, 15:186–189, Jan. 1877.

[8] C. Fontanive and D. Bardalez Gagliuffi. The Census of Exoplanets in Visual Binaries: population trends from a volume-limited Gaia DR2 and literature search. *Frontiers in Astronomy and Space Sciences*, 8:16, Mar. 2021. doi: 10.3389/fspas.2021.625250.

[9] A. S. Hamers and S. F. Portegies Zwart. White dwarf pollution by planets in stellar binaries. *Mon. Not. R. Astron. Soc.*, 462:L84–L87, Oct. 2016. ISSN 0035-8711. doi: 10.1093/mnrasl/slw134.

[10] J. B. Holberg, T. D. Oswalt, E. M. Sion, M. A. Barstow, and M. R. Burleigh. Where are all the Sirius-like binary systems? *Mon. Not. R. Astron. Soc.*, 435(3):2077–2091, Nov. 2013. doi: 10.1093/mnras/stt1433.

[11] N. A. Kaib, S. N. Raymond, and M. Duncan. Planetary system disruption by Galactic perturbations to wide binary stars. *Nat.*, 493(7432):381–384, Jan. 2013. doi: 10.1038/nature11780.

[12] B. Katz, S. Dong, and D. Kushnir. Luminosity function suggests up to 100 white dwarfs within 20 pc may be hiding in multiple systems. *arXiv e-prints*, art. arXiv:1402.7083, Feb. 2014. doi: 10.48550/arXiv.1402.7083.

[13] K. M. Kratter and H. B. Perets. Star Hoppers: Planet Instability and Capture in Evolving Binary Systems. *Astrophys. J.*, 753(1):91, July 2012. doi: 10.1088/0004-637X/753/1/91.

[14] M. Moe and R. Di Stefano. Mind Your Ps and Qs: The Interrelation between Period (P) and Mass-ratio (Q) Distributions of Binary Stars. *Astrophys J., Sup.*, 230(2):15, June 2017. doi: 10.3847/1538-4365/aa6fb6.

[15] A. J. Mustill, M. B. Davies, S. Blunt, and A. Howard. Dynamical orbital evolution scenarios of the wide-orbit eccentric planet HR 5183b. *Mon. Not. R. Astron. Soc.*, 509(3):3616–3625, Jan. 2022. doi: 10.1093/mnras/stab3174.

[16] L. A. Pearce, A. L. Kraus, T. J. Dupuy, M. J. Ireland, A. C. Rizzuto, B. P. Bowler, E. K. Birchall, and A. L. Wallace. Orbital Motion of the Wide Planetary-mass Companion GSC 6214-210 b: No Evidence for Dynamical Scattering. *Astronom. J.*, 157(2):71, Feb. 2019. doi: 10.3847/1538-3881/aafacb.

[17] L. A. Pearce, A. L. Kraus, T. J. Dupuy, A. W. Mann, E. R. Newton, B. M. Tofflemire, and A. Vanderburg. Orbital Parameter Determination for Wide Stellar Binary Systems in the Age of Gaia. *Astrophys. J.*, 894(2):115, May 2020. doi: 10.3847/1538-4357/ab8389.

[18] L. A. Pearce, A. L. Kraus, T. J. Dupuy, A. W. Mann, and D. Huber. Boyajian's Star B: The Co-moving Companion to KIC 8462852 A. *Astrophys. J.*, 909(2):216, Mar. 2021. doi: 10.3847/1538-4357/abdd33.

[19] L. A. Pearce, J. R. Males, A. J. Weinberger, J. D. Long, K. M. Morzinski, L. M. Close, and P. M. Hinz. Companion mass limits for 17 binary systems obtained with binary differential imaging and MagAO/Clio. *Mon. Not. R. Astron. Soc.*, 515(3):4487–4504, Sept. 2022. doi: 10.1093/mnras/stac2056.

[20] L. A. Pearce, J. R. Males, S. Y. Haffert, L. M. Close, J. D. Long, A. L. McLeod, J. M. Knight, A. D. Hedglen, A. J. Weinberger, O. Guyon, M. Kautz, K. Van Gorkom, J. Lumbres, L. Schatz, A. Rodack, V. Gasho, J. Kueny, W. Foster, K. M. Morzinski, and P. M. Hinz. HIP 67506 C: MagAO-X confirmation of a new low-mass stellar companion to HIP 67506 A. *Mon. Not. R. Astron. Soc.*, 521(3):4775–4784, May 2023. doi: 10.1093/mnras/stad859.

[21] H. B. Perets. Planets in Evolved Binary Systems. In S. Schuh, H. Drechsel, and U. Heber, editors, *Planetary Systems Beyond the Main Sequence*, volume 1331 of *American Institute of Physics Conference Series*, pages 56–75, Mar. 2011. doi: 10.1063/1.3556185.

[22] C. Petrovich and D. J. Muñoz. Planetary Engulfment as a Trigger for White Dwarf Pollution. *Astrophys. J.*, 834:116, Jan. 2017. ISSN 0004-637X. doi: 10.3847/1538-4357/834/2/116.

[23] K. D. Putirka and S. Xu. Polluted white dwarfs reveal exotic mantle rock types on exoplanets in our solar neighborhood. *Nat. Commun.*, 12:6168, Nov. 2021. ISSN 2041-1723. doi: 10.1038/s41467-021-26403-8.

[24] J. J. Ren, R. Raddi, A. Rebassa-Mansergas, M. S. Hernandez, S. G. Parsons, P. Irawati, P. Rittipruk, M. R. Schreiber, B. T. Gänsicke, S. Torres, H. J. Wang, J. B. Zhang, Y. Zhao, Y. T. Zhou, Z. W. Han, B. Wang, C. Liu, X. W. Liu, Y. Wang, J. Zheng, J. F. Wang, F. Zhao, K. M. Cui, J. R. Shi, and H. Tian. The White Dwarf Binary Pathways Survey. V. The Gaia White Dwarf Plus AFGK Binary Sample and the Identification of 23 Close Binaries. *Astrophys. J.*, 905(1):38, Dec. 2020. doi: 10.3847/1538-4357/abc017.

[25] A. P. Stephan, S. Naoz, and B. Zuckerman. Throwing Icebergs at White Dwarfs. *Astrophys. J. Let.*, 844(2):L16, Aug. 2017. doi: 10.3847/2041-8213/aa7cf3.

[26] D. Veras. Post-main-sequence planetary system evolution. *Royal Society Open Science*, 3:150571, Feb. 2016. doi: 10.1098/rsos.150571.

[27] D. Veras, A. J. Mustill, B. T. Gänsicke, S. Redfield, N. Georgakarakos, A. B. Bowler, and M. J. S. Lloyd. Full-lifetime simulations of multiple unequal-mass planets across all phases of stellar evolution. *Mon. Not. R. Astron. Soc.*, 458(4):3942–3967, June 2016. doi: 10.1093/mnras/stw476.

[28] D. Veras, N. Georgakarakos, I. Dobbs-Dixon, and B. T. Gänsicke. Binary star influence on post-main-sequence multi-planet stability. *Mon. Not. R. Astron. Soc.*, 465:2053–2059, Feb. 2017. ISSN 0035-8711. doi: 10.1093/mnras/stw2699.

[29] D. Veras, S. Xu, and A. Rebassa-Mansergas. The critical binary star separation for a planetary system origin of white dwarf pollution. *Mon. Not. R. Astron. Soc.*, 473:2871–2880, Jan. 2018. ISSN 0035-8711. doi: 10.1093/mnras/stx2141.

[30] B. Willems and U. Kolb. Detached white dwarf main-sequence star binaries. *Astronomy & Astrophysics*, 419:1057–1076, June 2004. doi: 10.1051/0004-6361:20040085.

[31] S. Xu and A. Bonsor. Exogeology from Polluted White Dwarfs. *Elements*, 17(4):241, Aug. 2021. doi: 10.48550/arXiv.2108.08384.

[32] B. Zuckerman. The Occurrence of Wide-orbit Planets in Binary Star Systems. *Astrophys. J.*, 791: L27, Aug. 2014. ISSN 0004-637X. doi: 10.1088/2041-8205/791/2/L27.

[33] B. Zuckerman, D. Koester, C. Melis, B. M. Hansen, and M. Jura. The Chemical Composition of an Extrasolar Minor Planet. *Astrophys. J.*, 671(1):872–877, Dec. 2007. doi: 10.1086/522223.

Data Management Plan

Data Products: Data associated with this project will include imaging and spectroscopic data obtained from astronomical instrumentation (fits files) and code used to reduce and analyze the data.

Data Storage and Computation: I anticipate that 4 TB of storage will be necessary to manage the instrument data, which I will store locally on an external hard drive. Some instruments may also maintain an archive for data storage, but not all. I will maintain local copies of all instrument data files used in this survey. The data analysis code will be maintained on my local machine, on Dropbox, and on my personal GitHub.

Data and Research Product Dissemination: I will make all data reduction and analysis code publicly available on my GitHub account. I will share my methods and results with the scientific community via peer reviewed publications, with my GitHub repositories clearly associated with each paper. I anticipate that my research will result in three publications over the course of the three year fellowship. I also maintain a robust research website in which I will summarize my work in public-friendly language and provide links to resources I generate for the community.

Broader Impacts: I will produce a website for the Student Veterans Research Symposium with all public-facing information and products relating to the symposium. Internal documentation will be hosted on a Google drive and enable collaboration while producing the symposium. Data collected on participation and demographic information will be privately maintained and not accessible to the public. The event will also be documented on my personal website.

Facilities, Equipment, and Other Resources

Data collection for my research will be conducted at the Magellan Clay Telescope at Las Campanas Observatory in Chile using the MagAO-X instrument, at the Subaru Telescope in Hawai'i using the SCExAO instrument, at the Keck II Telescope in Hawai'i using the HIRES instrument, and at local telescopes at Kitt Peak in Arizona. Magellan and the Arizona telescopes are maintained by Steward Observatory and accessed via Steward's time allocation committee (TAC), Keck is maintained by the Keck Observatory and accessed via their TAC, and Subaru is maintained by NOAJ and access via their TAC.

My proposed research analysis will primarily be completed on a laptop or desktop, as stated in the Data Management Plan. Large or long analysis computations can be completed using the high-performance computing facilities at Steward Observatory. I will require a 4TB hard drive to store the data.

The Student Veteran Research Symposium will make use of the University of Arizona room facilities and catering services. We will work with UA to reserve adequate rooms for the seminar, keynote speaker, poster hall, and conference dinner.

THE UNIVERSITY OF ARIZONA
COLLEGE OF SCIENCE
Astronomy
& Steward Observatory

Buell T. Jannuzi
Head & Director
Department of Astronomy
Steward Observatory
URL: www.as.arizona.edu

933 North Cherry Avenue
P.O. Box 210065
Tucson, AZ 85721-0065
Telephone: (520) 621-6524
buelljannuzi@email.arizona.edu

October 11, 2023

National Science Foundation
Astronomy and Astrophysics Postdoctoral Fellowship Office

To Whom it May Concern:

We are writing in regard to Logan Pearce's application for a NSF AAPF. Her proposed scientific mentor, Olivier Guyon, has reviewed her research proposal. The University of Arizona (UA) will welcome her here and offer her full support and access to facilities if a Fellowship is awarded. Fellows and postdocs are fully integrated into the educational and research activities at UArizona, including teaching courses if they express an interest in gaining teaching experience, participating in research activities and seminars, and have access to all telescopes, observatory labs, and computing facilities under the operation of the UArizona. The proposed Student Veteran Research Symposium aligns with the UA's mission to serve veteran student population, especially in STEM, and complements UA's ASEMS-V program, a partnership between Arizona's Science, Engineering, and Math Scholars (ASEMS) Program to get veterans into STEM research experiences.

Professor Olivier Guyon has agreed to collaborate with and mentor Logan Pearce in the research aspect of this project. Logan will be able to interact and collaborate with an excellent group of faculty and researchers in our department, and her past collaboration with campus veteran services provides a foundation for the success of the proposed educational program. Logan has demonstrated high levels of engagement in the educational, outreach and research activities of Steward Observatory throughout her PhD experience, and we are confident she will continue to do so as a postdoctoral researcher.

Sincerely,

Dr. Buell T. Jannuzi
Head, Department of Astronomy &
Director, Steward Observatory

Dr. Olivier Guyon
Astronomer
Steward Observatory

NSF MPS-Ascend

PROJECT SUMMARY

OVERVIEW:

Doctoral Granting Institution and state: University of Arizona, Arizona
Current position: Graduate Researcher
Current Institution and state: University of Arizona, Arizona
Proposed Host Institution and state: University of Arizona, Arizona
Proposed Scientific Mentor: Olivier Guyon
Proposed Duration: 36 months
Secondary unit of Consideration: Division of Astronomical Sciences

White dwarf stars' (WDs) strong gravities cause elements to stratify leaving pure hydrogen and/or helium photospheres; any metals observed in their photosphere spectra (called pollution) provide one of the only probes of exoplanetary material refractory composition. The mechanism for deposition of material onto the WD surface is not well understood. Understanding of the dynamical influence of a wide stellar companion on the planetary regime is hampered by low population statistics, particularly for WDs with AFGK stars (called "Sirius-Like Systems", SLS) where the WD's contribution to the spectral energy distribution is drowned out by the brighter main sequence star. While there is some research on influence of a wide stellar companion on the formation of exoplanets, a population study of the pollution rates of SLS will probe the influence of a wide stellar companion of the planetary regime for mature systems following the AGB phase of the host.

Extending her previous work with the extreme adaptive optics (ExAO) instrument MagAO-X, Logan Pearce, the proposer, has designed an extensive observational survey to detect new SLS and examine the WD for pollution called The ExAO Pup Search. The Pup Search will use the ExAO instruments MagAO-X and SCExAO to detect new systems, astrometric and RV monitoring to constrain orbits, and spectroscopy from HST and Keck/HIRES to look for pollution. This program will be carried out at Steward Observatory at the University of Arizona, which provides unparalleled access to the resources required for the program, with the sponsoring scientist Dr. Olivier Guyon.

INTELLECTUAL MERIT:

The data-set produced by the Pup Search will be invaluable to both the exoplanet and white dwarf communities. It will produce a new population of SLS and (un)polluted white dwarfs which will grow the sample size of these systems to enable population-level studies of pollution rates and orbital characteristics. It will provide more pollution measurements of the refractory compositions of exoplanetary material, and probe the influence of a wide stellar companion post-AGB phase. It will also provide observations for comparison to theoretical predictions of the orbital parameters for which the wide companion would be contributing to driving material onto the WD surface.

BROADER IMPACTS:

Veterans are a statistically underrepresented group in higher education, and their retention lags peers, particularly in STEM fields. Student veterans face a unique set of challenges to completing undergraduate STEM degrees, but getting them involved in STEM research in labs and research groups can help mitigate some of these challenges. Building on the success of student veteran research programs at the University of Arizona, Pearce will produce the Student Veterans Research Symposium to showcase the science being conducted by undergrad, graduate, and post-doctoral veterans to promote community, increase visibility, promote professional development, and showcase achievements. The Symposium will begin with local area universities and grow to a national event. Pearce will work with Dr. Jared Males, NSF, and UA stakeholders to organize and fund the Symposium.

PROJECT DESCRIPTION

INTRODUCTION AND BACKGROUND

I intend to pursue a career as an observational astronomer in the field of high-contrast imaging and exoplanet science. As a PhD student and NSF GRFP fellow at the University of Arizona (UA), I used the MagAO-X instrument, one of the newest cutting-edge high-contrast imaging instruments, to detect new exoplanet, stellar, and white dwarf companions to main sequence stars and produce some of the first astrophysics published with this new instrument. I also collaborated with colleagues at NASA Ames Research Center, with support from the NSF INTERN program, to model exoplanet atmospheres and predict survey yields for GMagAO-X, the first-light coronagraphic instrument for the Giant Magellan Telescope that will detect and characterize hundreds of planets in the light they reflect from their host stars, something which has not been done before and is essential for the next phase of exoplanet science. As a student veteran and a “non-traditional" student, I have served my student veteran community in several ways both at UA and remotely.

With the support of this fellowship I will conduct novel research benefiting both the exoplanet and white dwarf science communities. My program will utilize ground-breaking new ground-based telescope high-contrast imaging instrumentation to detect new white dwarf companions to main sequence stars and study the pollution rates of white dwarfs in wide binary systems compared to single white dwarfs using ground- and space-based instrumentation, in order to study the influence of the wide companion on planets and planetesimals around the white dwarf, and to enable population-level statistics by uncovering new systems. In my Research Proposal section, I outline how my proposed survey will make a significant impact in multiple open questions in both the exoplanet and white dwarf fields.

Additionally, with the support of this fellowship I will continue to serve my student veteran community and encourage veteran participation in STEM research through the Student Veterans Research Symposium. Student veteran participation and graduation rates in STEM fields lags their non-veteran peers. Veterans face several barriers to success in STEM degrees not faced by non-veteran students, and are more likely to come from traditionally underrepresented groups in STEM such as first-generation college students and racial minorities. In my Broader Impacts section, I detail how participation in STEM research can mitigate some of these challenges and how the proposed symposium will help encourage participation in STEM research.

Research Project Description

The ExAO Pup Search:
Probing planets in wide binaries by leveraging the power of extreme adaptive optics towards White Dwarf + Main Sequence star systems

The ExAO Pup Search
The search for non-interacting white dwarf - main sequence binaries with MagAO-X and SCExAO

Objective: **The study of the pollution and orbital characteristics of non-interacting white dwarf/main sequence star systems provides a direct probe of the influence of the wide companion on the planetary region.**

Astronomical Context: Multiple star systems are an extremely common outcome of the star formation process, especially for higher-mass stars [18]. I am interested in the formation and dynamical evolution of planetary systems around one star in a wide binary — "S-type", as opposed to "P-type" (circumbinary) planets — under the gravitational influence of the wide stellar companion. It is becoming clear that S-type planets are not uncommon [9, 6, 7], and companions will exert gravitational influence on the planetary regime throughout the star's lifetime impacting the formation and survival of S-type planets. **Observational tests are critical for theoretical predictions of how and to what degree companions influence planetary systems throughout the star's lifetime.**

White Dwarf - Main Sequence polluted binaries are crucial to exoplanet research:
- *WD pollution is the only method of probing the non-volatile composition of exoplanetary material*
- *Polluted WDMS systems probe the formation and survival of exoplanetary material in wide binary systems*
- *Small population statistics currently hinder studies*
- *High-contrast imaging instruments and techniques are ideal for addressing this problem*

White dwarfs (WD) with (non-interacting) main sequence star companions (WDMS) are an excellent laboratory for probing the influence of a wide companion at late stages of planetary system evolution. Due to their extreme gravity, elements stratify on short timescales (minutes – years) leaving pure H and He photospheres. Any metals observed in the spectra of WDs, called pollution, were deposited recently from the planetary regime [39]. **WD pollution is the only method of probing the refractory compositions of exoplanetary material** [e.g. 41, 36, 43, 30]. WDs show pollution independent of cooling age [37], requiring a mechanism(s) to deposit material that is independent of age [29]. **A wide stellar companion is one such possible mechanism** [42, 29]. The role of the companion in driving material onto the WD is unknown, but may impact the planetary regime through: 1. pushing previously stable planet orbits into regions of chaotic orbits as the primary loses mass and the companion's orbit expands [42, 13], 2. evolving onto high-eccentricity orbits through external perturbations [5, 11, 38] inducing regions of chaos [2], 3. driving von-Zeipel-Kozai-Lidov oscillations [11, 19], 4. driving secular resonances [2], 5. pushing surviving planets onto close orbits [15], 6. inducing a 2nd or 3rd generation of planet formation [28].

Many of these scenarios produce observationally testable predictions. Stephan et al. [32] determined the distribution of orbital parameters for a WD polluted by the Eccentric Kozai-Lidov (EKL) mechanism to which the orbits of a population of polluted WDMS systems can be compared. Veras et al. [38, Fig 3] made predictions of companion semi-major axis and eccentricity combinations for which the primary's planetary regime is (un)stable at various stellar evolutionary phases which can be compared to (non-)polluted WDMS system architecture.

As one star evolves off the main sequence, they can either evolve into interacting or non-interacting systems [40]; non-interacting WDMS orbits expand as primary loses mass into a regime amenable to direct imaging instrumentation. Additionally, the number of known nearby white dwarfs is fewer than expected from stellar evolution — the "missing white dwarf" problem [14, 12]. For so-called 'Sirius-Like Systems" (SLS), a multiple system containing a white dwarf with a more-luminous K-type or earlier companion(s), the white dwarf contribution to the SED is drowned out by the more luminous MS star, and can't be easily detected. **This motivates probing this population via high-contrast imaging detection methods**.

INTELLECTUAL MERIT

My plan as an NSF fellow is to execute an observational survey to leverage the power of the new extreme adaptive optics (ExAO) instruments MagAO-X and SCExAO towards detection and characterization of SLS with a survey called The ExAO Pup Search: The extreme AO non-interacting white dwarf-main sequence binary system survey[1]. The Pup Search has three main objectives:

1. Detect new non-interacting WDMS binary systems with MagAO-X and SCExAO and observe new systems for pollution with VIS-X, HST, and Keck/HIRES
2. Monitor orbits of new and previously known resolved WDMS systems with imaging and radial velocity to determine prevalence of high-eccentricity orbits of MS companions for polluted WDs and compare to estimated orbital parameters for the binary to be influencing pollution, such as those in Stephan et al. 32 and Veras et al. 38 Fig 3.
3. Determine pollution rates for WDMS systems with VIS-X, HST, and Keck/HIRES, compare to single WDs and as a function of cooling age, and compare to estimates such as Veras et al. [39]

There is a demonstrated need in both exoplanet and WD communities for a dataset of this kind. We will grow the sample size of non-interacting white dwarf-main sequence binaries and produce observational tests of the role of wide companions on the planetary regime; as a byproduct we will also be contributing to the missing WD problem by identifying new WDMS systems in the local region and testing the wide companion influence on pollution. This proposed research addresses several gaps identified in the NASA/JPL Exoplanet Exploration Program Science Gap List (Stapelfeld & Mamajek, 2023, JPL Document No: 1792073-2) including SCI-14: Exoplanet interior structure and material properties and SCI-04: Planetary system architectures and occurrence rates.

We observed 5 Pup Search systems with MagAO-X in 2022 and detected at least one new WD companion (Figure 1), which demonstrates the effectiveness of this survey. Zuckerman [42] compiled 38 polluted WDMS and found that the companion suppresses the formation and/or long term stability of planets; they acknowledge that these are small-number statistics and call for further observational surveys with this goal in mind. It is possible that polluted WDMS may be rare, however a larger population size is required, which this survey will provide. It will also be challenging to detect pollution lines with VIS-X as optical metal lines are typically rare and weak; spectra in the 0.3-0.4 μm range with HST and Keck/HIRES is optimal for line detection. The smaller mirror of HST is not a challenge to spatial resolution moving to UV wavelengths as for both HST at 0.3μm and MagAO-X at 0.8μm, $1\lambda/D \approx 25$ mas, so new systems detected by MagAO-X should be accessible to HST in UV. The Keck/HIRES instrument offers high-resolution spectra from 0.3-0.9 μm, offering a broad spectral range covering multiple regimes with pollution lines. Additionally, orbital periods

[1]The name is a reference to the first known wide White Dwarf- Main Sequence system, Sirius AB discovered in 1844 by Friedrich Bessel when he observed changes in the proper motion of Sirius [3], first observed by Alvin Graham Clark [8], and confirmed as the second ever known WD via its spectrum obtained by Walter Adams [1]. Since Sirius A is the "Dog Star", Sirius B was nicknamed "The Pup"

for SLS can be long making orbital parameter determination difficult. Non-interacting WDMS orbital periods from 3–300,000 years are common [40]. The Pup Search is targeting objects close to the inner working angle of nearby stars, where periods are shorter and radial velocity will yield better orbit constraints. Astrometric and RV measurements made during this fellowship will contribute to long-term orbit monitoring of these systems for future orbit constraints beyond the fellowship period.

As a member of the MagAO-X team during my PhD I have had 24 hours MagAO-X observing time as PI awarded over 2 semesters, 18 of which were for preliminary Pup Search observations. The remaining 6 hours resulted in publication of a new binary system HIP 67506 AC [27]. I have extensive experience with long-period orbit monitoring [22, 23, 24] and with high-contrast image processing and data analysis [26, 27].

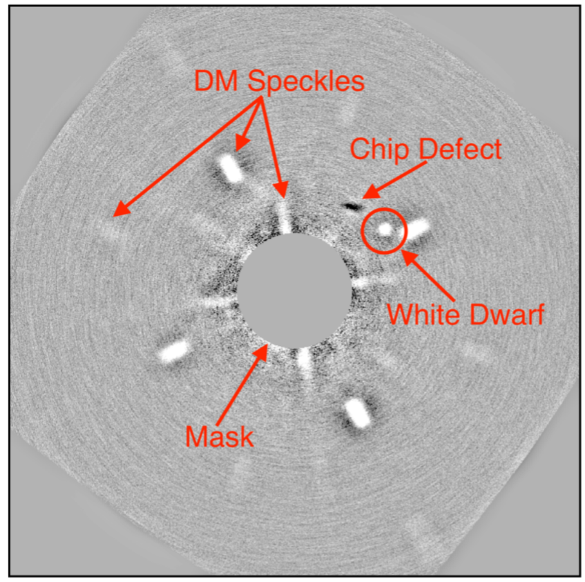


Figure 1: *A new WD companion (red circle) to a main sequence star discovered in i' band with MagAO-X in 2022 as part of the Pup Search program. Host star PSF was removed by unsharp mask and radial profile subtraction; mask, chip defect, and speckles caused by the deformable mirror are labeled. The new WD companion is indicated by the red circle.*

Timeline

Figure 2 displays a plan for the organization of this project. In year one my focus will be on detecting previously unknown WDMS systems with MagAO-X and SCExAO (Objective 1). As this process has already begun during my PhD, I already have a robust target list of MS stars highly likely to contain a hidden WD as selected by UV excess in Ren et al. [31], from which I have discovered at least one new WDMS (Figure 2). I will also compile a target list for orbit monitoring of known SLS and begin observations with other telescope resources (Objective 2). I expect publication of new WDMS detections at the end of year one. In year two I will continue Objective 1 and 2 observations and begin to shift focus to Objective 3 by applying for HST, Keck, and VIS-X time, with a second publication of new detections and preliminary orbit monitoring results expected near the end of year two. In year three my focus will primarily be on HST, Keck, and VIS-X spectroscopic observations, with publication of (un)polluted WDs and pollution rates expected near the end of year three.

Risk mitigation

This ambitious survey relies on the availability of primarily ground-based instruments, MagAO-X, SCExAO, and Keck, which are subject to observing and maintenance schedules, travel restrictions, and weather. MagAO-X's observing schedule was significantly impacted by COVID and related travel restrictions, and our 2022A observing run was hampered by weather, both of which would impact Objective 1. I will mitigate this risk by applying for time over multiple observing seasons on all instruments/telescopes. Objective 2 can be supplemented with other telescope resources, and HST observations of Objective 3 are not impacted by ground-based restrictions. Objective 3 relies on the availability of HST and Keck spectroscopy, with the main risk being continued availability of HST and being awarded HST and Keck observing hours for this program.

Outcomes

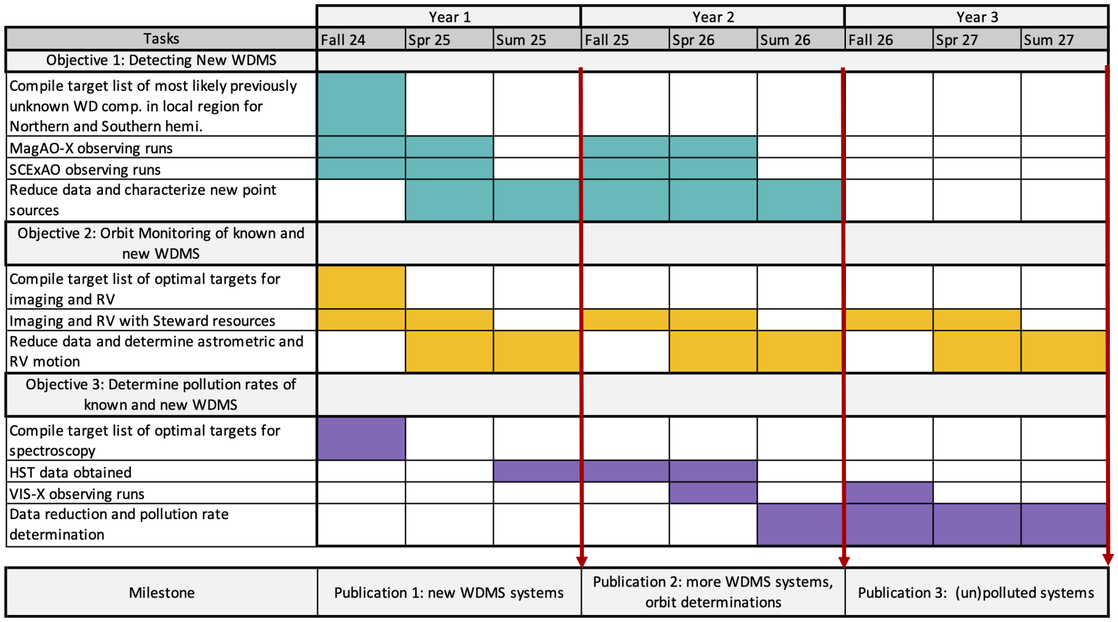


Figure 2: *Project plan and timeline*

Short term outcomes of the fellowship include providing the **exoplanet community** with a robust investigation of S-type planets in binaries at the end of the star's lifetime, with new WD pollution data providing more evidence of refractory compositions of exoplanets, and providing the **white dwarf community** with an expanded population of SLS. These data produced by this fellowship will be invaluable to both fields. This program builds upon all the strengths developed during my PhD while also pushing me into the new regimes of UV spectroscopy, radial velocity observations, and space-based observations. It enables me to build new professional relationships within the exoplanet community as well as forge new collaborations in the polluted white dwarf community.

Justification of Host Institution

The University of Arizona's Steward Observatory (hereafter UA) is the ideal institution to host the survey and broader impacts I am proposing. MagAO-X on the Magellan Clay Telescope, of which UA is a partner, is especially well suited to this science. It is built for extreme high contrast imaging on the order of 10^{-7}, so the contrasts involved in Sirius-Like Systems (SLS) [$\mathcal{O}(10^{-2} - 10^{-4})$] are easily achieved in short observation times. MagAO-X is optimized for optical wavelengths where WDMS star contrasts are much lower and inner working angles are smaller compared to IR-optimized high-contrast instruments. MagAO-X achieves exceedingly high Strehl ratio (a measure of the amount of light contained in the image core; $\sim 70\%$ in z') in optical wavelengths compared to other adaptive optics instruments. We also plan to use its high-resolution spectrograph, VIS-X, for spatially resolved spectra. While optical pollution features in white dwarfs are less common and harder to detect than UV, VIS-X will complement our planned UV HST and Keck/HIRES spectra. As a current member of the MagAO-X team I have already begun initial Pup Search observations with new white dwarf companion discoveries. Steward Observatory additionally offers a wealth of telescope resources for Pup Search Objective 2 - orbit monitoring of WDMS. In addition to the astrometry provided by MagAO-X, Steward offers access to several radial velocity instruments including the MIKE spectrograph at Magellan, NEID, and the Habitable Planet Finder (HPF) to complement the astrometry and provide better orbit constraints. Astrometry can also be supplemented with additional Steward resources like MMT/MAPS and LBT/SHARK-NIR or SHARK-VIS.

Due to the joint appointment of Dr. Olivier Guyon to Steward and NAOJ, hosting my fellowship at Arizona offers access to SCExAO, the extreme AO instrument on Subaru Telescope of which Dr. Guyon is the PI. This opens up the Pup Search survey to both northern and southern hemisphere targets. SCExAO/VAMPIRES offers a newly-commissioned four color imaging mode which enables fast color characterization of candidates to vet white dwarf status.

In addition to the expertise that Dr. Jared Males (MagAO-X PI) and Dr. Olivier Guyon (SCExAO PI) will lend to the success of this survey, there are a number of other faculty at Arizona that can provide additional support. Dr. Chad Bender (NEID PI and HPF team member) will be invaluable for the RV objective of this survey, as students and post-docs in Daniel Apai's and other exoplanet groups in Steward and Lunar Planetary Laboratory also on UA campus.

Additionally, while a grad student I have done work contributing to the science goals of GMagAO-X, the ExAO instrument our group is building for the GMT. GMT/GMagAO-X will be invaluable tools for WDMS characterization, in addition to detection and characterization of hundreds of exoplanets in reflected light. I am excited by the mission of GMagAO-X, and hosting my fellowship at Arizona will allow me to continue to collaborate on this vital instrument for the future of exoplanet direct imaging.

Finally, hosting my fellowship at Arizona is ideal for my diversity, equity, and inclusion efforts. In my Broader Impacts section I detail a proposal for a veteran-specific research symposium. Dr. Jared Males and I have begun the work of initiating this symposium at UA, including formulating a plan and beginning discussions with relevant University parties. This is an effort I care deeply about seeing through, and hosting my fellowship at UA will allow me to continue to build on work already begun.

After serving 5 years on active duty in the Navy and teaching 6 years in middle school, I have learned what it takes to thrive in my professional life. Given my previous professional experiences, and my already well established world-wide collaborator network, continuing my research program by hosting my fellowship at UA is the best match for me both personally and professionally. **There is no other US institution that offers comparable scientific resources for the accomplishment of my proposed research and the institutional and personnel resources for the proposed symposium.**

Broader Impacts

When I separated from the US Navy in 2008 after a 5 year career as an officer, I found it much more difficult to transition to civilian life than I had expected, both socially and professionally. I struggled to translate my experiences into a civilian-friendly resume, and to find a group of people who understood where I was coming from. When I decided to return to university for a bachelors degree in astronomy and physics in 2015, I connected with the Student Veterans Association at the University of Texas (UT), and found the kind of personally and professionally supportive community I wish I had had 7 years earlier.

Veterans are a statistically underrepresented group in higher education despite the numerous education benefits accompanying veteran status. Veterans are 7% of the US population over 18, yet they make up 3.7% of undergraduate students at the University of Arizona (UA), and 3.6% of STEM majors. At UA, veteran retention also lags compared to all students, with 31% of veteran STEM majors graduating after 6 years compared to 63% of all undergraduates[2]. The veteran population disproportionately comes from other underrepresented groups as well, such as racial minorities and first-generation college students. Veterans are significantly more likely to have dependents, military reserve obligations, and specific requirements related to education benefits (e.g. needing to take a full course load in order to receive a housing stipend), all of which can limit access to the kinds of opportunities that make graduate school applications stand out.

Veterans often don't realize how their military experience can be applied to STEM academics and careers. In addition to technical skills, veterans tend to underestimate the "soft skills" they've attained in the service, such as leadership and management, and how they can be leveraged for academic and research success. Many student veterans I've known were nervous about how their age and life experience makes them different from their college peers, something which actually is a major strength.

	Year 1			Year 2			Year 3		
	Fall 24	Spr 25	Sum 25	Fall 25	Spr 26	Sum 26	Fall 26	Spr 27	Sum 27
Local symposium for host institution and local community colleges		X							
Regional symposium including school from neighboring states					X				
National symposium								X	

Figure 3: *Symposium timeline*

Getting STEM-inclined veterans involved in STEM research in undergrad can increase retention by (1) helping them see past barriers such as difficult classes, (2) fostering community in academia by becoming contributing members of a research group, mitigating perceptions of otherness due to age and life-stage differences with peers, (3) fostering a sense of purpose by contributing meaningfully to active research, and (4) utilizing skills from service in a new way or uncovering new skills.

Budget	
Keynote speaker travel and accomodation	$1,000
Coffee, lunch, snacks throughout day	$1,000
Conference dinner/reception	$2,000
Total	$4,000

Figure 4: *Example Symposium budget for the first local Symposium.*

Building on the success of research conferences aimed at diversity and specific student groups, such as The Conference for Undergradute Women in Phyiscs (CUWiP) and the Society for Advancement of Chicanos/Hispanics & Native Americans in Science conference (SACNAS), **I propose to start the annual Student Veterans Research Symposium** at UA, a student veteran focused scientific research conference showcasing the research produced by veterans across disciplines at undergraduate, graduate, and post-doc levels. Together with my PhD advisor, Dr. Jared Males (also a US Navy veteran), we have already begun the work of refining this idea and taking the first steps at the University

[2] Source: UA Analytics as of 2020

of Arizona. The goal of the conference is to **promote community** among student veterans across disciplines, **increase visibility** of veteran researchers and encourage recruitment into research, **enable connection** for graduate programs looking to recruit student veterans, and **showcase the skills and achievements of veterans in STEM** research to encourage recruitment and retention of veterans. Taking place over two days, the conference will consist of multiple poster and/or talk sessions, workshops, and a keynote speaker. We plan to begin with local area universities initially, building eventually to a national conference. Figure 1 displays a proposed timeline; Figure 2 displays an example budget for the first local Symposium. I anticipate spending approximately 10% of my time on developing the conference, ramping up to 25% as the conference approaches. We will work closely with UA and NSF to fund the initial Symposium, and build on its success to expand funding for the larger events. We will track participation rates by veteran researchers, as well as attendance by non-veterans to assess the utility of this symposium. **The support of this fellowship at UA will enable me to continue this work and see the Symposium through to success.**

Career Development

I intend to pursue a career in astronomical research in exoplanet direct imaging. I will pursue research scientist positions at observatories, research facilities, or universities, however I will also consider faculty positions. As an NSF fellow at the University of Arizona, I will pursue my proposed and related research as well as continue my service to the student veteran community. In my postdoctoral career and beyond I will strive to meaningfully contribute to the exoplanet and white dwarf communities and provide a welcoming and supportive community for student veterans and non-traditional students. The support of this fellowship will enable not only research impacting two astronomical subfields but will enable me to continue work already begun serving the student veteran community at UA and eventually nationally.

Past Accomplishments and Results from Prior Support

Research: I was awarded the NSF GRFP in 2019 in the final year of my undergraduate experience at the University of Texas at Austin. I was on tenure status for the first three years and reserve for the remaining two years. During my GRPF fellowship I published three first-author peer reviewed journal articles [24, 26, 27], including the first astrophysics paper published with MagAO-X data [27], and made meaningful contributions to 10 peer-reviewed articles [17, 4, 21, 33, 20, 34, 6, 35, 25, 10]. I was awarded 24 hours of Magellan/MagAO-X as principal investigator for the initial Pup Search observations and observations resulting in the publication of a new binary star system [27], and 8 hours as Co-PI for an accelerating stars survey called Xoomies, which is still ongoing. I presented 9 invited and contributed science talks and 5 conference posters.

From April – Sep 2023 I completed a six month internship at NASA Ames Research Center in Mountain View, CA, with the support of the NSF INTERN program. I worked with Dr. Natasha Batalha, an expert in modeling exoplanet atmospheres and lead scientist of PICASO, an open-source python package for modeling atmospheres and producing model spectra. I produced a suite of models using PICASO of exoplanet reflected light spectra. Observing exoplanets in the light they reflect from their host star has never been done before but is the necessary next step in exoplanet science. Reflected light observations with MagAO-X are a few years away, and GMagAO-X on the GMT will detect and characterize hundreds of exoplanets in reflected light. I combined my reflected light models with an ExAO noise model [16] to produce survey yeild estimates and detection capabilities for reflected light imaging with MagAO-X and GMagAO-X. The work is ongoing but the models and exposure time estimates will be made available as a public service to the community. Publication of the models and analysis is expected in spring 2024.

Veteran Outreach: As detailed in the Broader Impacts section of this document, my status as a student veteran has been a significant part of my identity as a researcher. Thus I have been motivated to help my student veteran peers make the most of the opportunities available in undergraduate and graduate programs. As a PhD student at the University of Arizona I worked for three summers as a Research Project Leader for the Warrior Scholar Program (WSP), conducting week-long projects introducing scientific research and coding as part of WSP's two week "boot camp" for veterans transitioning into undergraduate programs. in 2022-2023 I worked for a full academic year as a consultant for WSP's Diana Davis Spencer Scholars program in which I gave workshops, shared resources, and gave application material feedback for a cohort of 25 WSP alumni who were applying for graduate school. I created and presented three professional development workshops with DDSS, and three different research projects with WSP, all of which are publicly available on my website and GitHub. Finally in 2021 I founded of the Student Veterans Research Network (SVRN), a peer network of graduate student veterans connecting across disciplines and across the country to support each other and share resources. In 2022 I presented SVRN at the Student Veterans of America National Conference in Orlando, FL. If funded through this fellowship, I intend to continue serving my veteran community as a postdoctoral researcher at the University of Arizona.

Other Outreach: In addition to my student veteran outreach detailed in the past accomplishments section, all of which occurred while on GRFP support, I also served as Lead Organizer for Astronomy on Tap (AoT) in Tucson. AoT is a worldwide organization of local public astronomy outreach talks in bars and breweries. In Tucson we operate as Space Drafts and host 2 talks and/or trivia every month at a local brewery. I lead a team of six to put on the show every month in a relaxed atmosphere making astronomy accessible and fun to a public audience.

I also worked for three semesters as a consultant with the UA GRFP Application Development Program, helping my peers craft compelling GRFP application materials. I maintain a robust personal website with numerous resources for graduate school and fellowship applications and professional science skills like talks and writing, and a blog with academia topics. I am committed to sharing the things learn when I learn them to help others succeed in academia and STEM.

References

[1] W. S. Adams. The Spectrum of the Companion of Sirius. *Pub. of the Astron. Soc. of the Pac.*, 27 (161):236, Dec. 1915. doi: 10.1086/122440.

[2] Á. Bazsó and E. Pilat-Lohinger. Fear the Shadows of the Giants: On Secular Perturbations in Circumstellar Habitable Zones of Double Stars. *Astronom. J.*, 160(1):2, July 2020. doi: 10.3847/1538-3881/ab9104.

[3] F. W. Bessel. On the variations of the proper motions of Procyon and Sirius. *Mon. Not. R. Astron. Soc.*, 6:136–141, Dec. 1844. doi: 10.1093/mnras/6.11.136.

[4] S. Blunt, J. J. Wang, I. Angelo, H. Ngo, D. Cody, R. J. De Rosa, J. R. Graham, L. Hirsch, V. Nagpal, E. L. Nielsen, L. Pearce, M. Rice, and R. Tejada. orbitize!: A Comprehensive Orbit-fitting Software Package for the High-contrast Imaging Community. *Astron. J.*, 159(3):89, Mar. 2020. doi: 10.3847/1538-3881/ab6663.

[5] A. Bonsor and D. Veras. A wide binary trigger for white dwarf pollution. *Mon. Not. R. Astron. Soc.*, 454:53–63, Nov. 2015. ISSN 0035-8711. doi: 10.1093/mnras/stv1913.

[6] S. Christian, A. Vanderburg, J. Becker, D. A. Yahalomi, L. Pearce, G. Zhou, K. A. Collins, A. L. Kraus, K. G. Stassun, Z. de Beurs, G. R. Ricker, R. K. Vanderspek, D. W. Latham, J. N. Winn, S. Seager, J. M. Jenkins, L. Abe, K. Agabi, P. J. Amado, D. Baker, K. Barkaoui, Z. Benkhaldoun, P. Benni, J. Berberian, P. Berlind, A. Bieryla, E. Esparza-Borges, M. Bowen, P. Brown, L. A. Buchhave, C. J. Burke, M. Buttu, C. Cadieux, D. A. Caldwell, D. Charbonneau, N. Chazov, S. Chimaladinne, K. I. Collins, D. Combs, D. M. Conti, N. Crouzet, J. P. de Leon, S. Deljookorani, B. Diamond, R. Doyon, D. Dragomir, G. Dransfield, Z. Essack, P. Evans, A. Fukui, T. Gan, G. A. Esquerdo, M. Gillon, E. Girardin, P. Guerra, T. Guillot, E. K. K. Habich, A. Henriksen, N. Hoch, K. I. Isogai, E. Jehin, E. L. N. Jensen, M. C. Johnson, J. H. Livingston, J. F. Kielkopf, K. Kim, K. Kawauchi, V. Krushinsky, V. Kunzle, D. Laloum, D. Leger, P. Lewin, F. Mallia, B. Massey, M. Mori, K. K. McLeod, D. Mékarnia, I. Mireles, N. Mishevskiy, M. Tamura, F. Murgas, N. Narita, R. Naves, P. Nelson, H. P. Osborn, E. Palle, H. Parviainen, P. Plavchan, F. J. Pozuelos, M. Rabus, H. M. Relles, C. Rodríguez López, S. N. Quinn, F.-X. Schmider, J. E. Schlieder, R. P. Schwarz, A. Shporer, L. Sibbald, G. Srdoc, C. Stibbards, H. Stickler, O. Suarez, C. Stockdale, T.-G. Tan, Y. Terada, A. Triaud, R. Tronsgaard, W. C. Waalkes, G. Wang, N. Watanabe, M.-S. Wenceslas, G. Wingham, J. Wittrock, and C. Ziegler. A Possible Alignment Between the Orbits of Planetary Systems and their Visual Binary Companions. *Astronom. J.*, 163(5):207, May 2022. doi: 10.3847/1538-3881/ac517f.

[7] A. Eggenberger, S. Udry, and M. Mayor. Statistical properties of exoplanets. III. Planet properties and stellar multiplicity. *Astronomy & Astrophysics*, 417:353–360, Apr. 2004. doi: 10.1051/0004-6361:20034164.

[8] C. Flammarion. The Companion of Sirius. *Astronomical register*, 15:186–189, Jan. 1877.

[9] C. Fontanive and D. Bardalez Gagliuffi. The Census of Exoplanets in Visual Binaries: population trends from a volume-limited Gaia DR2 and literature search. *Frontiers in Astronomy and Space Sciences*, 8:16, Mar. 2021. doi: 10.3389/fspas.2021.625250.

[10] J. Hagelberg, L. D. Nielsen, O. Attia, V. Bourrier, L. Pearce, J. Venturini, J. N. Winn, F. Bouchy, L. G. Bouma, C. Briceño, K. A. Collins, A. B. Davis, J. D. Eastman, P. Evans, N. Grieves, N. M. Guerrero, C. Hellier, M. I. Jones, D. W. Latham, N. Law, A. W. Mann, M. Marmier, G. Ottoni, D. J. Radford, N. Restori, A. Rudat, L. Dos Santos, S. Seager, K. Stassun, C. Stockdale, S. Udry, S. Wang, and C. Ziegler. TOI-858 B b: A hot Jupiter on a polar orbit in a loose binary. *arXiv e-prints*, art. arXiv:2309.11390, Sept. 2023. doi: 10.48550/arXiv.2309.11390.

[11] A. S. Hamers and S. F. Portegies Zwart. White dwarf pollution by planets in stellar binaries. *Mon. Not. R. Astron. Soc.*, 462:L84–L87, Oct. 2016. ISSN 0035-8711. doi: 10.1093/mnrasl/slw134.

[12] J. B. Holberg, T. D. Oswalt, E. M. Sion, M. A. Barstow, and M. R. Burleigh. Where are all the Sirius-like binary systems? *Mon. Not. R. Astron. Soc.*, 435(3):2077–2091, Nov. 2013. doi: 10.1093/mnras/stt1433.

[13] N. A. Kaib, S. N. Raymond, and M. Duncan. Planetary system disruption by Galactic perturbations to wide binary stars. *Nat.*, 493(7432):381–384, Jan. 2013. doi: 10.1038/nature11780.

[14] B. Katz, S. Dong, and D. Kushnir. Luminosity function suggests up to 100 white dwarfs within 20 pc may be hiding in multiple systems. *arXiv e-prints*, art. arXiv:1402.7083, Feb. 2014. doi: 10.48550/arXiv.1402.7083.

[15] K. M. Kratter and H. B. Perets. Star Hoppers: Planet Instability and Capture in Evolving Binary Systems. *Astrophys. J.*, 753(1):91, July 2012. doi: 10.1088/0004-637X/753/1/91.

[16] J. R. Males, M. P. Fitzgerald, R. Belikov, and O. Guyon. The Mysterious Lives of Speckles. I. Residual Atmospheric Speckle Lifetimes in Ground-based Coronagraphs. *Pub. of the Astron. Soc. of the Pac.*, 133(1028):104504, Oct. 2021. doi: 10.1088/1538-3873/ac0f0c.

[17] A. W. Mayo, V. M. Rajpaul, L. A. Buchhave, C. D. Dressing, A. Mortier, L. Zeng, C. D. Fortenbach, S. Aigrain, A. S. Bonomo, A. Collier Cameron, D. Charbonneau, A. Coffinet, R. Cosentino, M. Damasso, X. Dumusque, A. F. Martinez Fiorenzano, R. D. Haywood, D. W. Latham, M. López-Morales, L. Malavolta, G. Micela, E. Molinari, L. Pearce, F. Pepe, D. Phillips, G. Piotto, E. Poretti, K. Rice, A. Sozzetti, and S. Udry. An 11 Earth-mass, Long-period Sub-Neptune Orbiting a Sun-like Star. *Astron. J.*, 158(4):165, Oct. 2019. doi: 10.3847/1538-3881/ab3e2f.

[18] M. Moe and R. Di Stefano. Mind Your Ps and Qs: The Interrelation between Period (P) and Mass-ratio (Q) Distributions of Binary Stars. *Astrophys J., Sup.*, 230(2):15, June 2017. doi: 10.3847/1538-4365/aa6fb6.

[19] A. J. Mustill, M. B. Davies, S. Blunt, and A. Howard. Dynamical orbital evolution scenarios of the wide-orbit eccentric planet HR 5183b. *Mon. Not. R. Astron. Soc.*, 509(3):3616–3625, Jan. 2022. doi: 10.1093/mnras/stab3174.

[20] E. R. Newton, A. W. Mann, A. L. Kraus, J. H. Livingston, A. Vanderburg, J. L. Curtis, P. C. Thao, K. Hawkins, M. L. Wood, A. C. Rizzuto, A. Soubkiou, B. M. Tofflemire, G. Zhou, I. J. M. Crossfield, L. A. Pearce, K. A. Collins, D. M. Conti, T.-G. Tan, S. Villeneuva, A. Spencer, D. Dragomir, S. N. Quinn, E. L. N. Jensen, K. I. Collins, C. Stockdale, R. Cloutier, C. Hellier, Z. Benkhaldoun, C. Ziegler, C. Briceño, N. Law, B. Benneke, J. L. Christiansen, V. Gorjian, S. R. Kane, L. Kreidberg, F. Y. Morales, M. W. Werner, J. D. Twicken, A. M. Levine, D. R. Ciardi, N. M. Guerrero, K. Hesse, E. V. Quintana, B. Shiao, J. C. Smith, G. Torres, G. R. Ricker, R. Vanderspek, S. Seager, J. N. Winn, J. M. Jenkins, and D. W. Latham. TESS Hunt for Young and Maturing Exoplanets

(THYME). IV. Three Small Planets Orbiting a 120 Myr Old Star in the Pisces-Eridanus Stream. *Astron. J.*, 161(2):65, Feb. 2021. doi: 10.3847/1538-3881/abccc6.

[21] L. D. Nielsen, R. Brahm, F. Bouchy, N. Espinoza, O. Turner, S. Rappaport, L. Pearce, G. Ricker, R. Vanderspek, D. W. Latham, S. Seager, J. N. Winn, J. M. Jenkins, J. S. Acton, G. Bakos, T. Barclay, K. Barkaoui, W. Bhatti, C. Briceño, E. M. Bryant, M. R. Burleigh, D. R. Ciardi, K. A. Collins, K. I. Collins, B. F. Cooke, Z. Csubry, L. A. dos Santos, P. Eigmüller, M. M. Fausnaugh, T. Gan, M. Gillon, M. R. Goad, N. Guerrero, J. Hagelberg, R. Hart, T. Henning, C. X. Huang, E. Jehin, J. S. Jenkins, A. Jordán, J. F. Kielkopf, D. Kossakowski, B. Lavie, N. Law, M. Lendl, J. P. de Leon, C. Lovis, A. W. Mann, M. Marmier, J. McCormac, M. Mori, M. Moyano, N. Narita, D. Osip, J. F. Otegi, F. Pepe, F. J. Pozuelos, L. Raynard, H. M. Relles, P. Sarkis, D. Ségransan, J. V. Seidel, A. Shporer, M. Stalport, C. Stockdale, V. Suc, M. Tamura, T. G. Tan, R. H. Tilbrook, E. B. Ting, T. Trifonov, S. Udry, A. Vanderburg, P. J. Wheatley, G. Wingham, Z. Zhan, and C. Ziegler. Three short-period Jupiters from TESS. HIP 65Ab, TOI-157b, and TOI-169b. *Astronomy & Astrophysics*, 639:A76, July 2020. doi: 10.1051/0004-6361/202037941.

[22] L. A. Pearce, A. L. Kraus, T. J. Dupuy, M. J. Ireland, A. C. Rizzuto, B. P. Bowler, E. K. Birchall, and A. L. Wallace. Orbital Motion of the Wide Planetary-mass Companion GSC 6214-210 b: No Evidence for Dynamical Scattering. *Astronom. J.*, 157(2):71, Feb. 2019. doi: 10.3847/1538-3881/aafacb.

[23] L. A. Pearce, A. L. Kraus, T. J. Dupuy, A. W. Mann, E. R. Newton, B. M. Tofflemire, and A. Vanderburg. Orbital Parameter Determination for Wide Stellar Binary Systems in the Age of Gaia. *Astrophys. J.*, 894(2):115, May 2020. doi: 10.3847/1538-4357/ab8389.

[24] L. A. Pearce, A. L. Kraus, T. J. Dupuy, A. W. Mann, and D. Huber. Boyajian's Star B: The Co-moving Companion to KIC 8462852 A. *Astrophys. J.*, 909(2):216, Mar. 2021. doi: 10.3847/1538-4357/abdd33.

[25] L. A. Pearce, J. R. Males, A. J. Weinberger, J. D. Long, K. M. Morzinski, L. M. Close, and P. M. Hinz. Companion mass limits for 17 binary systems obtained with binary differential imaging and MagAO/Clio. *Mon. Not. R. Astron. Soc.*, 515(3):4487–4504, Sept. 2022. doi: 10.1093/mnras/stac2056.

[26] L. A. Pearce, J. R. Males, A. J. Weinberger, J. D. Long, K. M. Morzinski, L. M. Close, and P. M. Hinz. Companion mass limits for 17 binary systems obtained with binary differential imaging and MagAO/Clio. *Mon. Not. R. Astron. Soc.*, 515(3):4487–4504, Sept. 2022. doi: 10.1093/mnras/stac2056.

[27] L. A. Pearce, J. R. Males, S. Y. Haffert, L. M. Close, J. D. Long, A. L. McLeod, J. M. Knight, A. D. Hedglen, A. J. Weinberger, O. Guyon, M. Kautz, K. Van Gorkom, J. Lumbres, L. Schatz, A. Rodack, V. Gasho, J. Kueny, W. Foster, K. M. Morzinski, and P. M. Hinz. HIP 67506 C: MagAO-X confirmation of a new low-mass stellar companion to HIP 67506 A. *Mon. Not. R. Astron. Soc.*, 521(3):4775–4784, May 2023. doi: 10.1093/mnras/stad859.

[28] H. B. Perets. Planets in Evolved Binary Systems. In S. Schuh, H. Drechsel, and U. Heber, editors, *Planetary Systems Beyond the Main Sequence*, volume 1331 of *American Institute of Physics Conference Series*, pages 56–75, Mar. 2011. doi: 10.1063/1.3556185.

[29] C. Petrovich and D. J. Muñoz. Planetary Engulfment as a Trigger for White Dwarf Pollution. *Astrophys. J.*, 834:116, Jan. 2017. ISSN 0004-637X. doi: 10.3847/1538-4357/834/2/116.

[30] K. D. Putirka and S. Xu. Polluted white dwarfs reveal exotic mantle rock types on exoplanets in our solar neighborhood. *Nat. Commun.*, 12:6168, Nov. 2021. ISSN 2041-1723. doi: 10.1038/s41467-021-26403-8.

[31] J. J. Ren, R. Raddi, A. Rebassa-Mansergas, M. S. Hernandez, S. G. Parsons, P. Irawati, P. Rittipruk, M. R. Schreiber, B. T. Gänsicke, S. Torres, H. J. Wang, J. B. Zhang, Y. Zhao, Y. T. Zhou, Z. W. Han, B. Wang, C. Liu, X. W. Liu, Y. Wang, J. Zheng, J. F. Wang, F. Zhao, K. M. Cui, J. R. Shi, and H. Tian. The White Dwarf Binary Pathways Survey. V. The Gaia White Dwarf Plus AFGK Binary Sample and the Identification of 23 Close Binaries. *Astrophys. J.*, 905(1):38, Dec. 2020. doi: 10.3847/1538-4357/abc017.

[32] A. P. Stephan, S. Naoz, and B. Zuckerman. Throwing Icebergs at White Dwarfs. *Astrophys. J. Let.*, 844(2):L16, Aug. 2017. doi: 10.3847/2041-8213/aa7cf3.

[33] A. Vanderburg, S. A. Rappaport, S. Xu, I. J. M. Crossfield, J. C. Becker, B. Gary, F. Murgas, S. Blouin, T. G. Kaye, E. Palle, C. Melis, B. M. Morris, L. Kreidberg, V. Gorjian, C. V. Morley, A. W. Mann, H. Parviainen, L. A. Pearce, E. R. Newton, A. Carrillo, B. Zuckerman, L. Nelson, G. Zeimann, W. R. Brown, R. Tronsgaard, B. Klein, G. R. Ricker, R. K. Vanderspek, D. W. Latham, S. Seager, J. N. Winn, J. M. Jenkins, F. C. Adams, B. Benneke, D. Berardo, L. A. Buchhave, D. A. Caldwell, J. L. Christiansen, K. A. Collins, K. D. Colón, T. Daylan, J. Doty, A. E. Doyle, D. Dragomir, C. Dressing, P. Dufour, A. Fukui, A. Glidden, N. M. Guerrero, X. Guo, K. Heng, A. I. Henriksen, C. X. Huang, L. Kaltenegger, S. R. Kane, J. A. Lewis, J. J. Lissauer, F. Morales, N. Narita, J. Pepper, M. E. Rose, J. C. Smith, K. G. Stassun, and L. Yu. A giant planet candidate transiting a white dwarf. *Nat.*, 585(7825):363–367, Sept. 2020. doi: 10.1038/s41586-020-2713-y.

[34] A. Venner, A. Vanderburg, and L. A. Pearce. True Masses of the Long-period Companions to HD 92987 and HD 221420 from Hipparcos-Gaia Astrometry. *Astron. J.*, 162(1):12, July 2021. doi: 10.3847/1538-3881/abf932.

[35] A. Venner, L. A. Pearce, and A. Vanderburg. An edge-on orbit for the eccentric long-period planet HR 5183 b. *Mon. Not. R. Astron. Soc.*, 516(3):3431–3446, Nov. 2022. doi: 10.1093/mnras/stac2430.

[36] D. Veras. Post-main-sequence planetary system evolution. *Royal Society Open Science*, 3:150571, Feb. 2016. doi: 10.1098/rsos.150571.

[37] D. Veras, A. J. Mustill, B. T. Gänsicke, S. Redfield, N. Georgakarakos, A. B. Bowler, and M. J. S. Lloyd. Full-lifetime simulations of multiple unequal-mass planets across all phases of stellar evolution. *Mon. Not. R. Astron. Soc.*, 458(4):3942–3967, June 2016. doi: 10.1093/mnras/stw476.

[38] D. Veras, N. Georgakarakos, I. Dobbs-Dixon, and B. T. Gänsicke. Binary star influence on post-main-sequence multi-planet stability. *Mon. Not. R. Astron. Soc.*, 465:2053–2059, Feb. 2017. ISSN 0035-8711. doi: 10.1093/mnras/stw2699.

[39] D. Veras, S. Xu, and A. Rebassa-Mansergas. The critical binary star separation for a planetary system origin of white dwarf pollution. *Mon. Not. R. Astron. Soc.*, 473:2871–2880, Jan. 2018. ISSN 0035-8711. doi: 10.1093/mnras/stx2141.

[40] B. Willems and U. Kolb. Detached white dwarf main-sequence star binaries. *Astronomy & Astrophysics*, 419:1057–1076, June 2004. doi: 10.1051/0004-6361:20040085.

[41] S. Xu and A. Bonsor. Exogeology from Polluted White Dwarfs. *Elements*, 17(4):241, Aug. 2021. doi: 10.48550/arXiv.2108.08384.

[42] B. Zuckerman. The Occurrence of Wide-orbit Planets in Binary Star Systems. *Astrophys. J.*, 791: L27, Aug. 2014. ISSN 0004-637X. doi: 10.1088/2041-8205/791/2/L27.

[43] B. Zuckerman, D. Koester, C. Melis, B. M. Hansen, and M. Jura. The Chemical Composition of an Extrasolar Minor Planet. *Astrophys. J.*, 671(1):872–877, Dec. 2007. doi: 10.1086/522223.

Steward Observatory
933 N. Cherry Ave.
Tucson, AZ 85721

THE UNIVERSITY OF ARIZONA

Tel: (520) 485-9699
jrmales@arizona.edu

October 17, 2023

Dear NSF Program Coordinator,

If the proposal submitted by Logan Pearce entitled "The ExAO Pup Search: Probing planets in wide binaries by leveraging extreme adaptive optics towards White Dwarf + Main Sequence star systems" is selected for funding by NSF, it is my intent to collaborate and/or commit resources as detailed in the Project Description or the Facilities, Equipment and Other Resources section of the proposal. Sincerely,

Jared R. Males
Associate Astronomer
Steward Observatory
University of Arizona

THE UNIVERSITY OF ARIZONA
COLLEGE OF SCIENCE
Astronomy
& Steward Observatory

Buell T. Jannuzi
Head & Director
Department of Astronomy
Steward Observatory
URL: www.as.arizona.edu

933 North Cherry Avenue
P.O. Box 210065
Tucson, AZ 85721-0065
Telephone: (520) 621-6524
buelljannuzi@email.arizona.edu

October 17, 2023

Dear MPS-Ascend Fellow Coordinator:

As Department Head, I have reviewed the scientific mentor statement for Logan Pearce and hereby state my overall support and commitment to provide the necessary Departmental resources described in the statement.

Sincerely,

Dr. Buell T. Jannuzi
Head, Department of Astronomy &
Director, Steward Observatory

THE UNIVERSITY OF ARIZONA
COLLEGE OF SCIENCE
Astronomy
& Steward Observatory

Department of Astronomy
Steward Observatory
URL: www.as.arizona.edu

933 North Cherry Avenue
P.O. Box 210065
Tucson, AZ 85721-0065
Telephone: (520) 621-2288

October 17, 2023

Dear MPS-Ascend Fellow Coordinator:

As the Subaru Coronagraphic Extreme Adaptive Optics (SCExAO) group lead, I am the main supervisor of 3 postdoctoral fellows and 2 graduate students, and at any given time I co-supervise and work closely with ~10 graduate students and ~5 postdoctoral fellows. The students and postdoctoral fellows come from diverse backgrounds, with near parity in gender, diverse academic backgrounds (astronomy, optics and computer science), and geographical origin (US, Europe, Japan, India). I am committed to mentoring members of historically excluded and currently underrepresented groups, and have leveraged every opportunity I have had to do so. Specifically, I have welcomed in my team Hawaii-born students, which I actively seek by participating in local outreach activities and running the citizen science PANOPTES project I created. I am a partner to the Akamai Workforce Initiative, and I have mentored local Hawaii students through the program. I also currently supervise an African American PhD student, and support her ongoing efforts to promote optics among the African American community. I welcome the opportunity to work with Logan and Jared to reach out to the student veteran community, working towards a future mentorship.

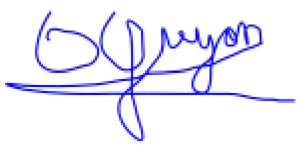
The SCExAO instrument is both a scientific instrument and a R&D platform supporting technology maturation efforts in adaptive optics and high contrast imaging. A key mission of the project is to provide a path for early career scientists (graduate students and postdoctoral fellows) to develop new approaches to high contrast imaging, including hardware (for example coronagraph masks, photonic devices for wavefront sensing), software (for example speckle control, wavefront control algorithms, PSF reconstruction) and innovative observational programs. In each of these areas, I have been, with my core team and extended network of collaborators, mentoring early career staff.

I am also an active member of the MagAO-X instrument team led by Dr. Jared Males. The two projects share common goals and the overlapping teams work together on several projects. Thanks to a common adaptive optics real-time control software framework, students and postdoctoral fellows can develop and test algorithms on both systems. Dr. Males and I have ensured that our team members and collaborators can work with both systems, both for instrumentation development projects and observing programs.

Logan's project leverages the capabilities of both MagAO-X and SCExAO. Both systems are in science operation, and routinely provide diffraction-limited optical wavelength high contrast imaging (HCI). Historically, HCI has mostly been done in the near-IR, and visible-light HCI, offering improved angular resolution, has only recently become possible thanks to advances in adaptive optics. SCExAO and MagAO-X have been optimized to operate in the visible, and are currently the leading visible light HCI systems. Logan's project requires visible-light HCI, so it is a perfect match to the MagAO-X and SCExAO capabilities, as white dwarfs emit the bulk of their light in the UV and optical.

I am personally committed to promoting short wavelength HCI on large telescopes, as it is key to observing reflected light habitable exoplanets on upcoming 30-m class telescopes. My academic work has been focused on achieving this goal, with the development of extreme AO techniques and coronagraphs able to operate at small angular separation.

On current (~6-10m diameter) telescopes, I am committed to both develop the required technologies, and assist observers with science programs that leverage short wavelength HCI capabilities. I am therefore committed to assisting Logan's research program. Logan's project overlaps with PSF calibration research I am now conducting with Dr Males (funded by a NSF ATI grant starting this year), as well as a NASA-funded project I lead for robust PSF calibration (also starting this year). I am looking forward to assisting Logan with data reduction, ensuring she will both benefit from these activities and she gains experience and knowledge in this emerging approach to adaptive optics HCI. My mentoring plan for Logan will be focused on achieving three goals: (1) ensuring timely completion of her observations at both MagAO-X and SCExAO systems, working closely with Logan and the instrument teams to optimize instrument configurations for her program, (2) planning with Logan observations, including follow-up characterization using spectroscopy (3) training Logan to leverage new tools and approaches in PSF calibration.



Dr. Olivier Guyon
Subaru Coronagraphic Extreme Adaptive Optics group lead
Subaru Telescope & University of Arizona
Mailing address: Subaru Telescope, 650 N. A'ohoku Place, Hilo, HI 96720
guyon@naoj.org
Phone: 818 293 8826

BUDGET JUSTIFICATION:

The requested duration is 36 months. A Budget Justification is not required for a MPS-Ascend proposal.

Data Management Plan

Data Products: Data associated with this project will include imaging and spectroscopic data obtained from astronomical instrumentation (fits files) and code used to reduce and analyze the data.

Data Storage and Computation: I anticipate that 4 TB of storage will be necessary to manage the instrument data, which I will store locally on an external hard drive. Some instruments may also maintain an archive for data storage, but not all. I will maintain local copies of all instrument data files used in this survey. The data analysis code will be maintained on my local machine, on Dropbox, and on my personal GitHub.

Data and Research Product Dissemination: I will make all data reduction and analysis code publicly available on my GitHub account. I will share my methods and results with the scientific community via peer reviewed publications, with my GitHub repositories clearly associated with each paper. I anticipate that my research will result in three publications over the course of the three year fellowship. I also maintain a robust research website in which I will summarize my work in public-friendly language and provide links to resources I generate for the community.

Broader Impacts: I will produce a website for the Student Veterans Research Symposium with all public-facing information and products relating to the symposium. Internal documentation will be hosted on a Google drive and enable collaboration while producing the symposium. Data collected on participation and demographic information will be privately maintained and not accessible to the public. The event will also be documented on my personal website.

Facilities, Equipment, and Other Resources

See Letters of Collaboration