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Recommendations on simple but transformative diversity, equity, and inclusion measures in Heliophysics over the next decade

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It is well established that, in order to perform at their peak ability, a person must feel accepted, safe, and valued at work. Therefore, it is imperative to bring Diversity, Equity, and Inclusion (DEI) efforts to the forefront of Heliophysics over the next decade and well beyond. This position paper outlines three specific recommendations to make the Heliophysics community more diverse, equitable, and inclusive by improving the accessibility and accountability. These recommendations are: performing consistent collection and analysis of demographic data across different agencies, reimagining undergraduate Heliophysics internships using the SOARS® model, and providing conference funding for DEI speakers whose expertise lies outside the field of Heliophysics. These targeted recommendations have a well-documented positive impact, are simple to implement, and follow other scientific communities' recent recommendations for making the science, technology, engineering, and mathematics fields more diverse, equitable, and inclusive.

KEYWORDS
diversity, equity, inclusion, space physics, demographics, internships, trainings

Introduction and motivation

The people who do the work in the scientific enterprise are, first and foremost, people with different lived experiences, all of which shape how they do science. In our continued pursuit to understand how the geospace environment affects our everyday lives, we cannot lose the perspective that we are just people. In this pursuit, it is well established that peak performance is only possible when one feels accepted, safe, and valued at work (e.g., Cho and Barak, 2008; Halkos and Bousinakis, 2010; Østergaard et al., 2011; AlShebli et al., 2018; Way et al., 2019; Haacker et al., 2022). Further, it is also well established that diverse groups are more innovative and produce better science outcomes than homogeneous groups (e.g., McLeod et al., 1996; NRC, 2015; Lerback et al., 2020). The opposite is also true: hostile and unsafe educational and work environments cause people to fail at tasks where they would have otherwise succeeded, or choose to leave the scientific enterprise (e.g., Watson, 2019; Donovan, 2021). For example, several studies have highlighted how the negative and biased attitudes and interactions between students and faculty and amongst student peers significantly reduce the likelihood of women or students of color in science, engineering, technology, and math (STEM) to successfully finish their undergraduate STEM education (e.g., Price, 2010; Gayles and Ampaw, 2014; Bradforth et al., 2015; Thiry et al., 2019). Therefore, it is imperative that diversity, equity, and inclusion (DEI) efforts be brought to the forefront of Heliophysics over the next decade and well beyond, not only from a productivity standpoint, but also because we should value every voice in Heliophysics, past, present, and future.

Before proceeding further, it is important to define what is meant by diversity, equity, and inclusion; three words that will appear a number of times throughout this position paper. To do so, we follow the definition offered in Pendergrass et al. (2019), and originally from Rodriguez (2016) for diversity and equity, and Jordan (2011) for inclusion.

- Diversity involves the recognition of the visible and invisible physical and social characteristics that make an individual or group of individuals different from one another, and by doing so, celebrating that difference as a source of strength for the community at large (p. 242, Rodriguez, 2016).

Pendergrass et al. (2019) paraphrases from Yosso (2005), "Diverse lived experiences provide community cultural wealth in the form of aspirational, familial, social, navigational, resistant, and linguistic capitals that vary across the different stakeholders."

- Equity refers to the enactment of specific policies and practices that ensure equitable access and opportunities for success for everyone. It is important to differentiate equity from equality. In order to be equitable, we cannot treat everyone the same, but we must treat individuals according to their needs and provide multiple opportunities for success (p. 243, Rodriguez, 2016).

Pendergrass et al. (2019) states, "Equity is providing resources and structures that are not necessarily equal, but are equitable to ensure that all people can participate in the scientific activity."

- Inclusion involves bringing together and harnessing these diverse forces and resources, in a way that is beneficial. Inclusion puts the concept and practice of diversity into action by creating an environment of involvement, respect, and connection—where the richness of ideas, backgrounds, and perspectives are harnessed to create business value. Organizations need both diversity and inclusion to be successful (Jordan, 2011).

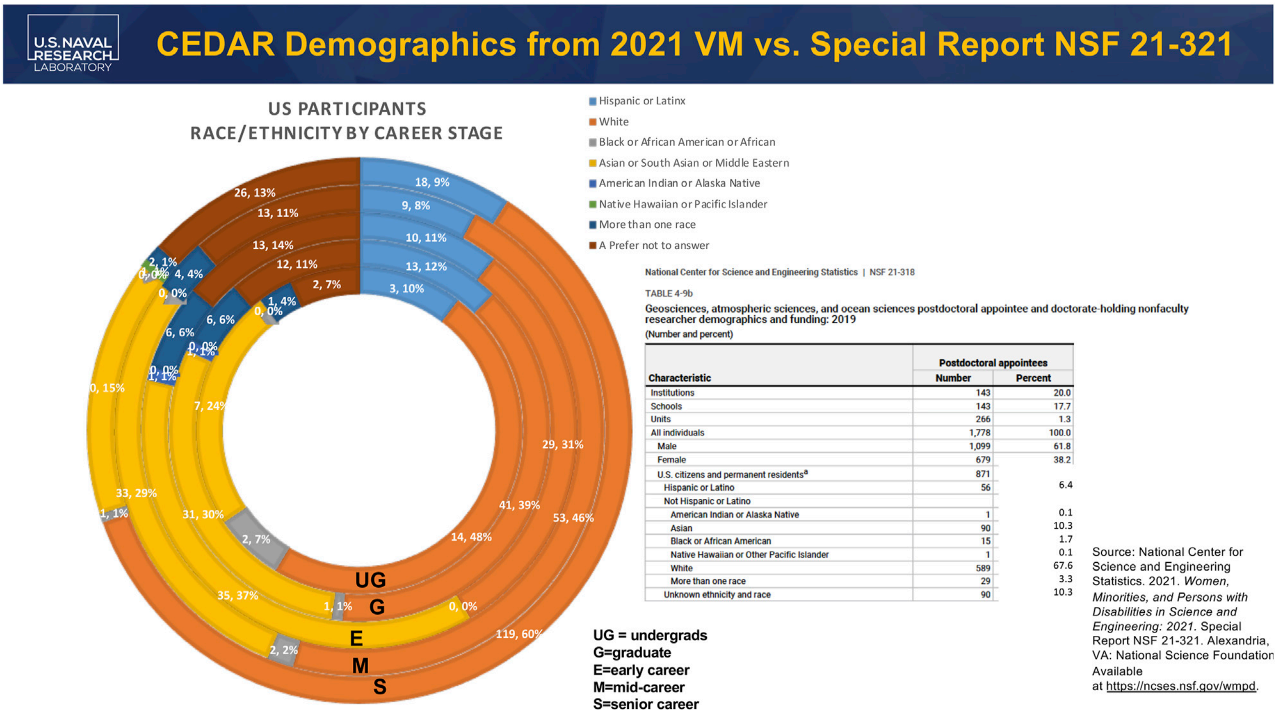
Pendergrass et al. (2019) states, "An inclusive environment transcends diverse representation. Without inclusive and respectful practices, a space can still be exclusionary of different perspective, even if it has presentation of diverse lived experiences."

Below we outline three concrete, simple, and transformative recommendations for making the Solar, Planetary, and Space Physics fields a more diverse, inclusive, and equitable space for all past, present, and future community members.

Consistent collection and analysis of demographic data across different agencies

Currently, there are a number of different efforts to reduce barriers associated with implicit and explicit bias in the scientific enterprise. However, it is impossible to understand the current landscape, make effective progress, set realistic goals, and assess recent changes without ample and consistent demographic data (e.g., Else and Perkel, 2022; NASEM, 2022). Without data, scientific organizations, policymakers, programs, and stakeholders have had difficulty implementing structural interventions that could be the catalyst for change. Put simply by Pendergrass et al. (2019), "demonstrating progress requires data."

However, certain scientific laboratories, organizations, and programs (e.g., Else and Perkel, 2022) lack sufficient data to adequately chart the state of DEI. For example, the National Academies of Sciences and Medicine (NASEM) Committee on Increasing Diversity and Inclusion in the Leadership of Competed Space Missions recently stated that, "There is currently no strategy and methodology being employed to effectively gather demographic data on participation in the Earth and space sciences along the whole career pathway—from undergraduate and graduate programs to academic departments and the professional workforce." Additionally (and also recently), the Decadal Survey on Astronomy and Astrophysics for the 2020s (NASEM, 2021) recommended the following: "Collect and report consistent demographic data from organizations that support astronomical research, education, and training. Data are key to identifying promising practices, measuring progress, and holding agencies and institutions accountable to equity-advancing values." Further, Decadal Survey Midterm Assessment (NASEM, 2020) in solar and space physics



Characteristic	Postdoctoral appointees Number	Percent
Institutions	143	20.0
Schools	143	17.7
Units	266	1.3
All individuals	1,778	100.0
Male	1,099	61.8
Female	679	38.2
U.S. citizens and permanent residents[a]	871	
Hispanic or Latino	56	6.4
Not Hispanic or Latino		
American Indian or Alaska Native	1	0.1
Asian	90	10.3
Black or African American	15	1.7
Native Hawaiian or Other Pacific Islander	1	0.1
White	589	67.6
More than one race	29	3.3
Unknown ethnicity and race	90	10.3

FIGURE 1
Example comparing race/ethnicity demographics of US Participants in the 2021 CEDAR Virtual Workshop versus NSF demographic information on Geosciences, atmospheric, and oceanic sciences Postdoctoral appointees in 2019 from the NCSES (2021).

recommendation 6.2 stated in part: "NASA Heliophysics Division should conduct a demographics/diversity survey before the next Heliophysics decadal survey to understand how the community's demographics have evolved and to assess whether progress has occurred in enhancing diversity in the community." We stand with previous recommendations from National Academies above, and insist that the collecting and recording of demographic data be a priority to better assess the state of the Heliophysics profession over the next decade.

Of course, all data sets are not equally valuable. It is vital that the demographic data be collected in a consistent manner, reporting the same types of information (e.g., same race/ethnicity groups, gender groups, career-stage groups, etc.) over an extended period of time. For example, NASA ROSES and NSF Proposal demographics could be combined and collected in a similar fashion since instrument, mission, and science proposals in Heliophysics and all its subdisciplines go to these (and many other) funding agencies. Collecting different types of demographic information can it make difficult to evaluate DEI in Heliophysics. An example, from Jones, (2021) presented at the 2021 AGU Fall Meeting is offered below. Figure 1 was attempting to try to compare race/ethnicity demographics by career stage from US participants at the 2021 CEDAR Virtual Workshop to NSF demographic information on Geosciences, atmospheric, and oceanic sciences Postdoctoral appointees from the NCSES (2021). Figure 1 illustrates the difficulty smaller scientific programs and societies have attempting to assess baseline DEI information quantitatively. Not only are the demographic categories different for the CEDAR statistics than those recorded by the National Center for Science and Engineering Statistics (NCSES), but so are the different career stages (e.g., CEDAR did not separate out between Postdocs and Early-Career).

To reiterate, we advocate this type of demographic data (e.g., career stage, race, ethnicity, gender identify, sex, etc.) should be collected in a consistent manner, reporting the same types of demographic information by the funding agencies and large scientific societies across Heliophysics. This demographic information, including the different categories should be made available to the community, to the fullest legal extent, which will hopefully facilitate their analysis and comparison with smaller program demographic information (e.g., CEDAR). This separate independent analysis would require additional funding and expertise too, through additional proposal calls at the funding institutions (e.g., beyond "Broader Impacts" in NSF Proposals) because, like any other research endeavor, this work takes time and expertise. Non-etheless, collecting, retaining, and sharing this consistent data over a long period of time provides a means to measure impact of different DEI efforts, while also creates accountability (Pendergrass et al., 2019) for all invested parties of Heliophysics, not just the historically marginalized groups.

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Reimagining undergraduate heliophysics Internship's using the SOARS model

Although the demographic information we currently compiled for the Heliophysics community are limited, they are still alarming when evaluating from a DEI perspective. For example, Garcia et al. (2021) reported on data from the U.S. Census Bureau and National Science Foundation, NCSES in 2019 that although people of color (i.e., Blacks/African Americans, Hispanics/Latina/o/x, Native Americans) made up ~33% of the U.S. population, they only made up ~12% of the graduate student population in STEM. Another example is offered by Bernard and Cooperdock (2018) who reported that there was no progress on ethnic and racial diversity among United States citizens and permanent residents who earned PhDs in Earth, atmospheric, and ocean sciences over a 40-year period. Chapter 4 in the recently released Advancing Diversity, Equity, Inclusion, and Accessibility in the Leadership of Competed Space Missions from the NASEM in 2022 revealed a number of issues regarding the "Pathways into Space Sciences" for women and underrepresented minorities. Two of the many key findings are as follows:

- "While women continue to be highly underrepresented in physics and astronomy at all levels, there does not currently appear to be similar attrition from undergraduate to PhD levels, and even at the early-career faculty."
- "Very low overall retention (~11%) in NASA SMD relevant disciplines during undergraduate training, and the accompanying racial/ethnic disparity (factor of ~3), is currently a major pinch point that restricts the size and diversity of the pool of PhD scientists for future NASA mission leadership."

Among a number of other factors (including structural racism and sexism, interpersonal attitudes, stereotypes, and implicit bias) this NASEM, 2022 report highlights the impact that a lack of opportunity for "early and ongoing" real research experiences has on the diversity in NASA Science Mission Directorate-related disciplines. Others (Thiry et al., 2019; Chang et al., 2014; Jones et al., 2010; and references therein) have reported on how co-op programs, internships and undergraduate research increase degree-completion rates for underrepresented minorities. Further, Haacker (2015) states that moving from recruitment to retention of underrepresented members of the scientific enterprise takes a long-term investment and mentoring at the undergraduate level that elevates a students' abilities, resources, and perseverance, eventually allowing them to "pay it forward."

A shining example of this type of undergraduate internship that one could argue has had a transformative impact is the SOARS® Program (Significant Opportunities in Atmospheric Research and Science, Windham et al., 2004). SOARS is a multi-year undergraduate-to-graduate bridge program that focuses on increasing the diversity of the atmospheric and related sciences, and in career pathways. The program allows historically underrepresented students in the sciences (including Black or African American, American Indian or Alaska Native, Hispanic or Latino, female, first-generation college students, and students with disabilities) to participate in scientific research projects over their summer breaks at leading geoscience research facilities throughout the country. As described by Haacker (2015), "Beyond just a research experience, the program provides a multi-pronged approach to supporting a student in their summer research and throughout their higher education and entry into the workforce. Students are paired not only with a research advisor, but also with mentors covering other aspects of being a scientist, including writing and public speaking, and programming. Perhaps most importantly, each student works with a formal peer mentor and a life coach to handle stress and help with life choices." Also, SOARS provides financial support to its students including undergraduate and possibly graduate school tuition assitance, and conference attendance to present their scientific results.

Further, the yearly cost for one SOARS Protégé, including their stipend, lodging, travel, conference attendance and travel, tuition support, etc. is ~$25,000 USD. While this approximate cost does not take into account all of the intangible "costs" associated with supporting a SOARS student (e.g., volunteer time by mentors, administrative work by the SOARS Staff), it does provide some idea of the financial value necessary to support a SOARS Protégé. This approximate cost, even over multiple years (SOARS offers Protégés the opportunity to participate for up to four (4) years), is a comparatively small investment relative to the cost of operating a major ground-based Heliophysics facility and/or launching and operating a Heliophysics spacecraft. The investment in people is necessary for research to continue, as well as for research to be integrative and inclusive, benefiting humankind.

Spanning the 26 + year history of the program, as of 2021, 250 students from historically underrepresented groups in STEM have participated in SOARS with 78 currently enrolled in Bachelors, Masters and Doctoral degree programs; 212 Bachelors degrees have been completed; 132 alumni have completed Masters-level advanced degrees; 52 alumni have earned Doctoral degrees; and 48 more are currently in PhD program with many alumni having multiple degrees at all levels. Note while SOARS is a factor in degree attainment, it is not the only factor. It is not a degree-granting institution or program, but rather a bridge program. However, given the NASEM, 2022 study found "The number of African Americans, Hispanic Americans, and Native Americans combined receiving PhDs in astronomy in any given year has never exceeded single digits, the number of African American PhDs in astronomy in any given year over the past decade has averaged ~1, and the number of Native American

PhDs in astronomy in any given year remain too small to count.", it is hard to refute the impact of a bridge program like SOARS.

For all of these above reasons we highly advise that Heliophysics support the creation of an undergraduate-to-graduate bridge program in the coming decade (and sooner) that is modeled using the best practices from the SOARS program. This is in line with the Conclusion 4-1 from the Advancing Diversity, Equity, Inclusion, and Accessibility in the Leadership of Competed Space Missions from the NASEM in 2022, which stated, "Significant and concerted efforts may be needed to ensure that the currently small pool of scientists of color have every opportunity to engage in NASA mission-related work and leadership." For example, NASA SMD is currently in the process of creating the SMD Bridge Program (https://science.nasa.gov/smd-bridge-program) and is currently holding various workshops to collaboratively create the Bridge Program. This position paper highly suggests following the existing, effective model of the SOARS Program to create or improve existing bridge programs, while following the five key strategies for increasing diverse student's perseverance and confidence outlined in Haacker (2015).

Conference and training funding for DEI speakers

Scientific meetings and workshops are a chance to learn, exchange ideas, collaborate, and build relationships within the community. However, there are a number of reasons why it might be difficult for some members of the community to attend or to be included from certain spaces of different meetings and workshops. These reasons include structural issues such as lack of travel funding, dependent care, safe bathroom spaces, accessibility issues, and safe, affordable housing. Interpersonal reasons include microaggressions and overt harassment (Haacker et al., 2020; Lauer et al., 2020). Recent scientific meetings are striving to combat these issues through the introduction of codes of conduct, improving the diversity of invited speakers, and including DEI-focused sessions (e.g., Gannon and Lugaz, 2020).

As Haacker et al. (2020) states, "we can only address underrepresentation and exclusion if we understand it as a collective problem that requires us all to commit to making conferences more creative and welcoming spaces." Including DEI-specific content does provide a venue for more creative and welcoming spaces at conferences, while also acknowledging that community members' lived experiences inform their scientific approach. DEI-specific content can improve the interpersonal interactions between conference attendees and through community building and education. Holding these sessions at conferences (especially during plenary sessions when most conference attendees are present) is also the only way to reach all members of the Heliophysics community, as these are the only type of events that members from all career stages and all types of institutions (academic, government, and industry) attend.

However, the quality of these sessions can undermine their intent. It is common for well-meaning, but ill-informed members of the Heliophysics community to advocate paths for improvement that go against the best practices established by experts in DEI related fields. It is also difficult to bring in experts on DEI-related topics (e.g., social scientists) to come to Heliophysics conferences, as their own research does not overlap with the Heliophysics disciplines. Providing funding support for travel, housing, and honorariums to those outside the Heliophysics fields specifically covered by the meeting to educate Heliophysics attendees about DEI-related issues in STEM and Heliophysics is vital.

These types of speakers do exactly as Haacker et al. (2020) says, "understand the collective problem." Understanding and bringing awareness to these issues, while also being informed about the best DEI practices, acts to create a cultural shift towards inclusion. This is important because within STEM disciplines, those of whom have been historically excluded, underrepresented or minoritized groups often feel an exclusionary climate, and that their own identity and value is incompatible with STEM culture (Griffin, 2018). Thus, one of the easiest, most straightforward ways to change this culture in Heliophysics is at meetings. Pendergrass et al. (2019) states the following, "participation is not only about who is in the space, but also about how they are doing in the space." Providing funding for DEI speakers, sessions, trainings, etc. is one of the many ways we can bring more people into Heliophysics, while also giving them a sense of belonging, letting them see we care about how they are doing as people in Heliophysics. A table of other Heliophysics professionals that support our position on the DEI measures suggested herein is included as Supplementary Material S1.

Data availability statement

No new or original datasets were used as part of this work. The table in Figure 1 was taken from NCSES data found at https://ncses.nsf.gov/pubs/nsf21321/.

Author contributions

MJ led the conceptualization and drafting of this manuscript. All authors contributed to manuscript citations, editing, revisions, reading, and approved the submitted version.

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Conflict of interest

Author JG was employed by the company Computational Physics, Inc.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fspas.2022.1062970/full#supplementary-material

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