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Gender Disparity in Publishing Six Months after the KITP Workshop Probes of Transport in Stars

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Abstract

Conferences and workshops shape scientific discourse. The Kavli Institute for Theoretical Physics (KITP) hosts long-term workshops to stimulate scientific collaboration that would not otherwise have taken place. One goal of KITP programs is to increase diversity in the next generation of scientists. In this analysis, we examine gender trends in the authorship of papers that have been generated as a result of the KITP program Probes of Transport in Stars, which ran from 2021 October 11th to 2021 December 17th. While 38% of workshop participants were women, only 19% of publications produced between 2021 December 1st and 2022 June 3rd had female first-authors. Furthermore, of these early publications, 61% had all-male author lists. Among publications resulting from the KITP program, the proportions of both male first-author papers and papers with all-male author lists are higher than predicted by models that take into account the gender distribution of the KITP participants. These results motivate more thorough investigations of collaboration networks at scientific conferences and workshops. Importantly, they also suggest that programs, conferences, and workshops of any kind need to take steps beyond those implemented in this KITP program to enable more diverse collaborations and address gender disparities in science.

Unified Astronomy Thesaurus concepts: Sociology of astronomy (1470)

1. Introduction

Many authors have discussed the impact of gender on astronomy careers, including the impacts on time allocation (Reid 2014; Patat 2016; Johnson & Kirk 2020; Carpenter et al. 2022), authorship and citation (Caplar et al. 2017), hiring (Flaherty 2018; Perley 2019; Kewley 2021), conference participation (Davenport et al. 2014; Pritchard et al. 2014; Schmidt et al. 2016; Schmidt & Davenport 2017), and involvement in collaborations (Lundgren et al. 2015; Lucatello & Diamond-Stanic 2017).

A method often employed in other fields is the study of authorship networks, the goal of which is understanding with whom people publish. In turn, this can serve as an imperfect indicator of their choice of collaborators (Katz & Martin 1997).

There has been significant discussion in the literature on whether authorship networks differ, on average, by gender. Initial results suggested that men have more collaborators, but when controlling for respondent seniority, data suggest that women actually have the same or perhaps even more collaborators than men, on average (Bozeman & Gaughan 2011; West et al. 2013). Some authors have found that women are more likely to collaborate with other women (Bozeman & Corley 2004; Karimi et al. 2019), men are more likely to collaborate with men (Bozeman & Gaughan 2011; Araújo et al. 2017), or both (Ferber & Teiman 1980; McDowell & Smith 1992; Jadidi et al. 2018), but the details of these findings are affected by other variables including career status, field, funding, strategy, and so on (e.g., Rhoten & Pfirman 2007).

Crucially, the literature suggests that wide, well-connected collaboration networks can be the key to long-term productivity for people of both genders (Kyvik & Teigen 1996; Jadidi et al. 2018, although see also Lee & Bozeman 2005). This makes it important to consider not only the intentions of workshops to increase inclusivity and enhance networks, but also their measurable impact on collaboration and publication.

In the Fall of 2021, the Kavli Institute for Theoretical Physics (KITP) ran a ten week program on Probes of Transport in Stars, as well as a week-long associated conference on *Transport in Stellar Interiors*. There were 45 in-person participants; 28 self-identified as male, and 17 self-identified as female. In the six months after the end of the program, defined as the period of 2021 December 1st through 2022 June 3rd, the in-person participants in the Probes of Transport in Stars program have authored a total of 94 papers/scientific

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contributions that have been uploaded to the arXiv. Of these scientific contributions (hereafter also "papers," interchangeably), we have identified 18 as being strongly associated with the KITP program. In this work, we investigate the gender distribution of the authors of these papers who were also program participants. Although our sample size is small, our study is significant in that it has isolated the (early) collaborative effects of a single workshop.

In the roughly six months following the end of the program, men have published disproportionately more than women (Section 4). We also show that men coauthored papers at a disproportionately higher rate than women. The number of papers with only male authors (among program participants) is much higher than if coauthors were chosen at random. Collectively, these and related findings point to significantly greater publication opportunities for men despite no apparent difference in the resources provided by KITP on the basis of gender (Section 2). A discussion of possible reasons for these biases and output discrepancies is given in Section 5. Suggestions for improving gender-based returns from future programs are given in Section 6.

2. Gender Goals of KITP Programs

As part of its mission to empower the next generation of scientists and foster collaborative networks (https://www.kitp.ucsb.edu/support-kitp), KITP requires program organizers to consider inclusivity seriously in the creation of a program. At the pre-proposal stage, organizers are required to suggest "2–4 organizers and 10–15 key participants, keeping in mind KITP's commitment to diversity and inclusion of under-represented groups." At the full proposal stage, KITP works with the organizers to "identify and attract a diverse set of scientists through an application and invitation process," and organizers are required to name a Diversity Coordinator as well as a "diverse list of Key Long Term Participants."

As recruitment begins, organizers are reminded that the program should be well advertised in order to attract a broad range of applicants from which a diverse pool of participants can be chosen. They are also encouraged to ensure that speakers and session chairs at the associated conference should be broadly diverse along a range of axes, including gender, race, under-representation, career stage, and so on. Before finalizing the program, KITP required a short report on these recruitment efforts, including demographic information on the proposed participants. In building the list of conference speakers, organizers were reminded that they "must consider the inclusion of groups underrepresented in physics." At the close of the program, coordinators were expected to do an exit interview as well as produce a report on the program itself, which included a review of "efforts at achieving participation by groups underrepresented in physics." KITP itself has also begun collecting data on collaboration networks and the impact

of programs, which will likely be extremely valuable and potentially influential in setting future policies.

2.1. The "Probes of Transport in Stars" Program

A specific goal of the Probes of Transport in Stars program was to encourage new collaborations, particularly between participants who are interested in similar astrophysical problems but normally use different approaches (3D simulations, 1D models, observations, analytical calculations, etc). During the participant selection process, the organizers kept statistics on the methodological expertise of the applicants, as well as demographic information including whether an applicant was likely part of an underrepresented minority. Ultimately, the constituency of in-person participants was 38% female. This is significantly better than the degree of female representation in professional astronomy (27% female) and even more so than in professional physics (20% female).[7]

A variety of mechanisms were put in place to encourage inter-speciality crosstalk and the creation of new projects:

1. Each week, the in-person schedule included an introduction and organization session on Monday mornings;
2. Several broad working groups were created that met once a week;
3. Formal talks to introduce various concepts and techniques happened twice a week;
4. Informal meetings on Fridays at which each participant was encouraged to bring and briefly present a plot representing their efforts over the week;
5. Participants were invited to group lunches many weekdays;
6. Group dinners were organized on Tuesdays and Fridays; and
7. A variety of social activities were organized and advertised by participants.

In addition to the in-person events, a KITP Slack workspace was open to all participants, and a set of Google Drive folders was created for the storage of working group notes and project efforts. Working group chairs and project leaders were encouraged to create a Slack channel for their project that included a description and summary of current work and to make these channels open to any participant (including remote participants) interested in joining. These channels were intended to permit collection and fragmentation as group interests dictated.

The week-long conference *Transport in Stellar Interiors* was organized to focus on discussions. Each three-hour session was divided into a 40 minute review talk (plus 20 minutes of questions), followed by a 20 minute research talk (plus ten for

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[7] according to the American Institute of Physics (AIP) records on gender (2019–2020): https://www.aip.org/statistics/data-graphics/percent-astronomy-faculty-members-who-are-women-2003-2020.

questions), followed then by a 90 minute panel discussion. The organizers prioritized junior researchers with a range of identities as speakers and panelists. During the conference itself, session chairs were reminded to be inclusive when mediating conversation and were provided with guidelines for inclusive chairing.

3. Data

For this analysis, "participation" in the KITP workshop refers only to in-person participation. By this metric, and excluding those who attended only the mid-program conference, there were 45 participating scientists in total.[8]

The data set was constructed first by performing a NASA ADS search on each of the 45 in-person participants over the date range 2021 December 1 to 2022 June 3. For an author named n, any paper on which n appears, in any position, is classified as "a paper by n." The total number of papers returned this way is 94, and the arXiv IDs for each of these scientific contributions are given in Table 2 in the Appendix.

Sub-classifying a paper published between 2021 December 1st and 2022 June 3rd by author n as a *KITP paper* by author n is attempted as follows. First, we define a "KITP paper" as any paper or other arXiv/ADS-supported scientific contribution whose inception or production began in one of three ways:

1. as a new idea while a portion of its authors were at KITP (and not before); or
2. as an iteration of an existing idea or goal whose actualization was only possible thanks to work at KITP; or
3. after KITP, but as a direct consequence of work performed at KITP, where such work includes the creation of collaboration networks.

One means of verifying a paper's membership in the *KITP paper* category is checking whether that paper includes the following grant acknowledgement or a variant thereof: `This research was supported in part by the National Science Foundation under Grant No. NSF PHY-1748958`. However, this is not a perfect indicator for a variety of reasons: among these, (1) whether citing this grant is justified or necessary is up to the author's discretion; (2) its citation, or lack of citation, may not reflect true working conditions for political or other ambiguous reasons; or (3) authors may simply have forgotten to cite KITP. We thus found that a qualitative method was most effective for determining whether work was enabled by the KITP program.

The definition of "arXiv/ADS-supported scientific contribution" (or "paper") extends to (RNAAS) notes, publication preprints (at any stage of refereeing, including unrefereed), novelty/recreational papers, and manuscripts not intended for

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Table 1
Definitions of Categorization Terms

Category Label	Definition
KITP Participant	an in-person participant in the KITP program for any number of weeks; excludes conference-only participants and remote-only participants
KITP author	a *KITP participant* whose name appears in any position on any paper published from Dec 1, 2021 to June 3, 2022
KITP Paper	any paper published by a KITP author whose production is credited to KITP (per Section 3)
all-female KITP paper	any *KITP paper* for which all *KITP authors*⋆ are female
all-male KITP paper	any *KITP paper* for which all *KITP authors*⋆ are male

Note. ⋆Note that such author lists may contain men (women), but those men (women) are not *KITP authors* by definition. As such, this is a measure of clustering among female/male *KITP participants*.

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publication in astronomy or physics journals. Conference proceedings were included where they were substantial enough to make it through arXiv moderation.

The number of papers identified as KITP papers according to these criteria is 18. Of these, 16 are led by a KITP author, which we define as an (in-person) program participant who appears somewhere on at least one paper published between 2021 December 1 and 2022 June 3. There is a potential maximum of 45 such authors, but in practice, fewer.

Many KITP papers have authors (including first authors) who are not KITP participants. In the subsequent analysis, we only study the gender breakdown of the *KITP participants* who were authors of these papers. We have self-identified genders for the KITP participants, but we do not have this information for other (non-KITP) authors on the papers. Furthermore, the goal of this work is to learn about collaboration patterns between KITP participants, specifically.

The categorizing definitions used in this analysis are summarized in Table 1.

3.1. Caveats

Social data are even more imperfect than astronomical data, and so our classification scheme comes with many caveats:

1. "KITP paper" is not a rigid definition. It is not straightforward to determine whether a piece of work has

come to fruition entirely, partially, or not at all due to KITP conditions. This is a subjective assessment that would, ideally, be made by each author individually for each paper on which they appear. However, it is not possible to collect these data on a reasonable timescale and without biasing our results. Where we have classified a paper as a *KITP paper*, we have done so using our best judgement: factoring in the author list, time of publication, the topic of publication, presence of grant acknowledgement, and firsthand knowledge of working groups, subject areas, and projects in progress during the workshop.

2. The arXiv does not capture works in progress, for example, works submitted to journals but still in revision or under consideration. The arXiv also cannot capture intangible benefits of collaboration, such as the formation of new (potential) author networks or the initialization of longer-term projects for which there is no searchable data product (yet).

3. Genders of the KITP authors and participants are taken to be those self-reported by those individuals. As part of KITP registration, individuals were given the option to choose from among `woman`, `man`, `non-binary`, or `"another identity not listed"` as identifiers. Use of the terms men/women and male/female throughout this manuscript shall not be taken to imply a lack of other gender identities, within this sample or outside of it.

4. Results

We summarize our quantitative findings below. Interpretation is reserved for Section 5.

We discuss our findings in the context of an "idealized environment" from which random gender selections are made. Such an environment assumes that women and men have no preference for or against their own gender when choosing collaborators and are exactly the same in terms of their ability to publish, opportunity to publish, access to the resources to publish, motivation to publish, and preference for publication style and type. The KITP participants were 38% female and 62% male (Figure 1). In an environment as described, we would expect the gender breakdown of KITP first authors to reproduce the participant ratio. In reality, of 16 KITP first authors (excluding two KITP papers that do not have a KITP participant as the first author), only three had female first-authors, while 13 had male first-authors. This is half the female first-author representation idealized conditions would be expected to produce.

In the left-most panel of Figure 2, we show the actual distribution of female-only, male-only, and mixed-gender KITP papers observed in the data. In the center and right-most panels, we show results from simulated distributions computed in two ways. The center panel shows the expected values for numbers of female-only, male-only, and mixed-

gender papers assuming a "Random Authors" model. In this model, the genders of authors for 18 synthetic papers are randomly drawn from a 38:62 F:M distribution, preserving the observed number of authors associated to each paper. In the right-most panel, we assume a "Random Coauthors" model. In this case, the reported genders of the first authors (Figure 1) are fixed. Then, each remaining coauthor's gender is randomly drawn as in the Random Authors model. This model yields somewhat, but not wildly, different expected values for the numbers of single-gender papers. The code to calculate these models as well as the scripts used to generate the data and figures in this paper can be found at https://github.com/lecoanet/KITP_gender.

We first note that the percentage of KITP papers containing at least one female KITP author is 39%, compared to an expected value of 64% from the Random Authors model or 58% from the Random Coauthors model. This shows that the actual proportion of KITP papers containing at least one female KITP author is significantly lower than what would be produced via random draw, even if the observed proportion of male first-authors were the same. On the other hand, the percentage of KITP papers containing at least one male KITP author is 89%. This is larger than the percentage of male KITP participants (which is 62%), larger than the expected number of papers containing a male author (82%) according to the Random Authors model, and slightly larger even than the expected number of such papers (87%) according to the Random Coauthors model. We comment on specific features of the gender distribution data below.

4.1. Low Proportion of Female First Authors

Of the 18 KITP papers, 16 have KITP participants as first authors. Only 19% of these had female first authors, which is lower by a factor of two than the fraction of female participants (Figure 1). Out of 16 papers, a random draw would produce 6 female-led KITP papers. We instead see three, and in all cases, the number of coauthors is either one or zero (in fact, this is true whether we consider KITP coauthors or coauthors of any kind). This is in stark contrast to male-led papers, which range in the number of KITP coauthors from zero to five (and up to dozens if including non-KITP coauthors).

4.2. Men Prefer Male Collaborators

Most KITP papers have all-male KITP author lists. Per Figure 2, of the 18 KITP papers, 11 have author lists with only male KITP participants (*all-male KITP papers*), whereas two have authors lists with only female KITP participants (*all-female KITP papers*). This constitutes a large over-representation of all-male papers even when taking into account the larger fraction of male first authors.

Figure 2 also makes clear that the degree of single-gender author clustering is much higher in the observed data than
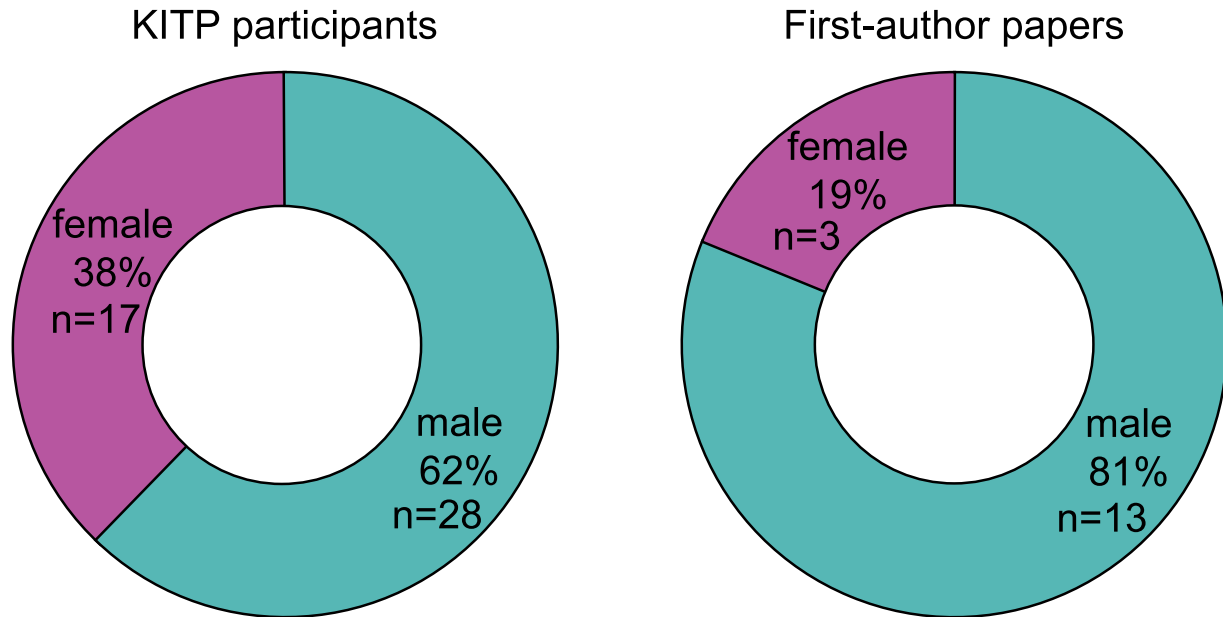
Figure 1. *Left:* Gender breakdown of KITP program participants. *Right:* Gender breakdown of the first-authors of KITP papers. We note that the first-authors of two KITP papers were not KITP participants, and so they are not included in the right-hand panel.
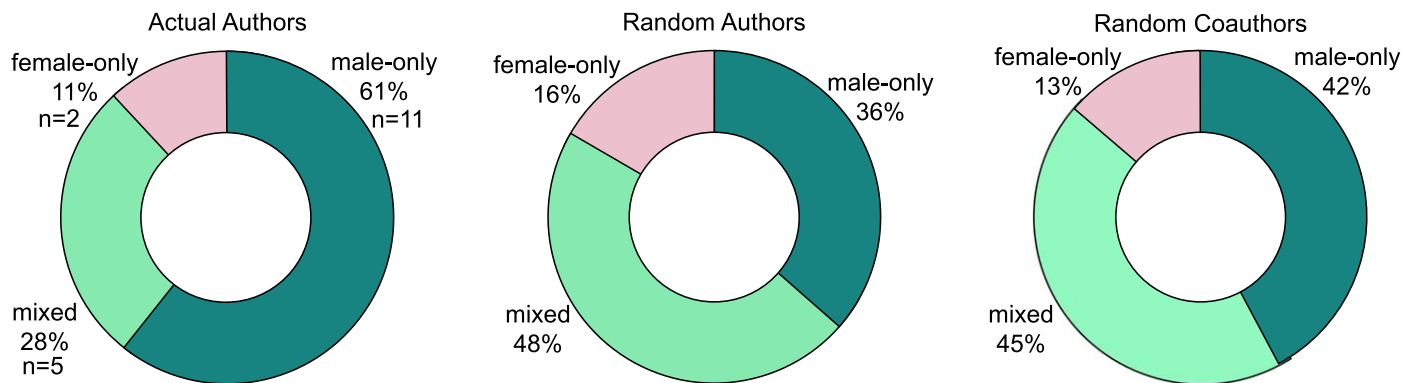

Figure 2. *Left:* Observed gender breakdown of KITP papers. *Center:* "Random Authors" model: the expected gender breakdown of authors of KITP papers, drawing from the 62-38 M:F ratio of the workshop. *Right:* "Random coauthors" model: the expected gender breakdown of the authors of KITP papers, using the observed gender breakdown of first authors, and drawing from the 62:38 M:F ratio of coauthors. Note that we only include the gender of KITP participants (for whom we have self-reported genders). Some "female-only" papers may include non–KITP-participant male authors, and some "male-only" papers may include non–KITP-participant female authors. The presence of additional (non-KITP) authors does not affect our assessment of the gender-based clustering within the KITP program.

predicted by either model. The proportion of all-male KITP papers (61%) alone exceeds the predicted number of mixed-gender papers by either model. When compared to the distribution generated by the Random Coauthors model, the true number of all-male KITP papers (61%) exceeds both the predicted number of all-male KITP papers (42%) and the expected number of papers that contain a female author in any position at all (58%). It is thus clear that male authorship is over-represented, by any measure, in the real data.

There are not enough data in the category of female-led publications to support inferences about women's gender

preferences among coauthors. However, the data on male-led papers demonstrate a clear preference among male leads for male coauthors.

To better understand the degree of over-representation and quantify how anomalous it is, we computed probability distributions for the numbers of male-only and female-only KITP papers under the assumptions of both the Random Authors and Random Coauthors models. Assuming the true gender breakdown of participants, we generate 10,000 random distributions and plot these as histograms. Results are shown in Figure 3.
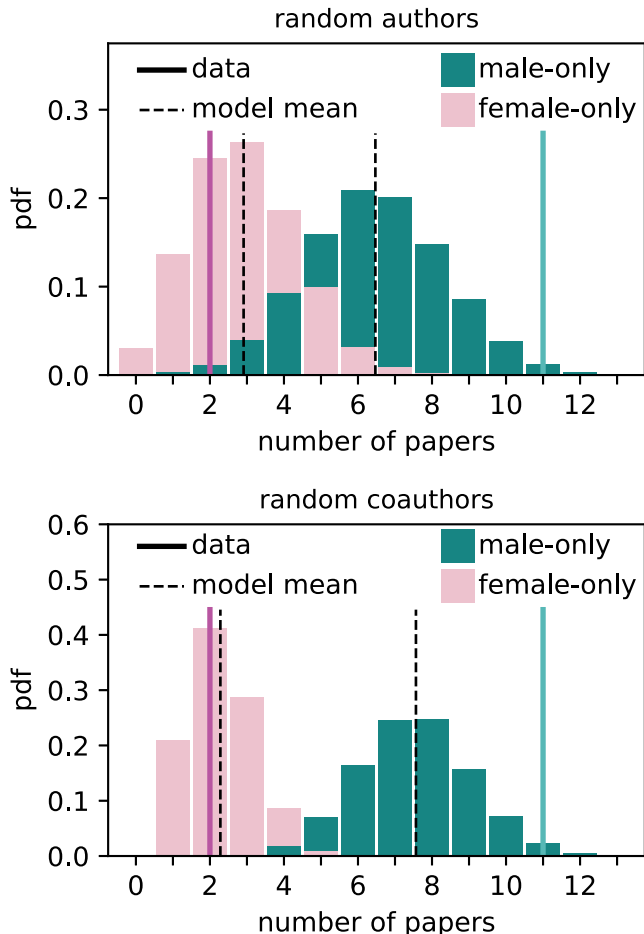
Figure 3. Probability distributions for the expected number of male-only and female-only papers assuming the Random Authors (top) and Random Coauthors (bottom) models are shown. Under the constraints of the former model, the expected number of female-only papers is 2.91 (standard deviation 1.45; vertical dashed line on the pink distribution), which over-predicts the observed number of female-only papers (solid pink line) by one (discretized). The expected number of all-male KITP papers, however, is 6.46 (standard deviation 1.87; vertical dashed line on the blue distribution), which is 5 papers (discretized) less than observed (solid blue line). Under the constraints of the latter model, the expected number of female-only papers is 2.28 (standard deviation 0.91), and the expected number of male-only papers is 7.57 (standard deviation 1.53; vertical dashed lines). In both models, the expected number of female-only papers (2.91 and 2.28) closely matches the observed number of female-only papers (2, solid line), but the expected number of male-only papers (6.46 and 7.57) is still very different from the observed value (11, solid line).

In the probability distribution built on the Random Authors model, the expected number of all-female papers is 2.91 (standard deviation 1.45) and the expected number of all-male KITP papers is 6.46 (standard deviation 1.87), indicated by dashed vertical lines in the centers of the respective distributions. The observed values are indicated as pink/blue solid lines for all-female and all-male, respectively. These lie at the far extremes of the probability distributions in opposite

directions. In the probability distribution built on the Random Coauthors model, the expected number of female-only papers is 2.28 (standard deviation 0.91) and the expected number of male-only papers is 7.57 (standard deviation 1.53). While the actual number of all-female papers (2) is near the peak of this distribution, there are still many more all-male papers (11) than would be expected if KITP coauthors were chosen at random. The probability of observing 11 or more male-only papers given these assumptions is $p = 0.03$. Thus, even taking into account the disproportionately large number of male first-authors of KITP papers, there is a demonstrable bias among male KITP authors in favor of collaborating with male KITP participants.

On the other hand, the true number of female-only papers is nearly the same as predicted by either model: two papers as compared to the (discretized) expected values of three papers (Random Authors) and two papers (Random Coauthors). As such, the models do indicate that the majority of single-gender clustering overall is the result of all-male groups. However, it is worth noting that two-thirds of (2 out of 3) KITP papers with female first-authors are female-only. This is higher than the same ratio for men, suggesting that female preference for female coauthors may also be a relevant dynamic. That said, it is difficult to draw meaningful conclusions from samples of this size, so we can neither confirm nor rule out single-gender clustering by female authors.

4.3. More Publication Opportunities for Men

Figure 4 is an extension of Figures 2 and 3, showing the gender breakdown of KITP author lists according to the number of KITP authors per paper. The true distribution (left column) is compared to synthetic distributions from the Random Authors (middle column) and Random Coauthors (right column) models. The indices align a given KITP paper to its simulated counterparts per row (and do not necessarily correspond to the indices assigned to arXiv identifiers in the Appendix).

Figure 4 provides a striking visual indication of how (early) publication opportunities associated with the KITP program were distributed by gender: men preferentially selected male collaborators, published more first-author papers, and dispro-portionately did not include women in their papers. Both models predict that the number of mixed-gender papers should exceed the number of all-male papers, but the data do not reflect this. The over-representation of all-male KITP papers found in the data is especially noticeable in papers with three or more coauthors, suggesting that the preference among men for male collaborators may be compounded as the number of male authors increases.
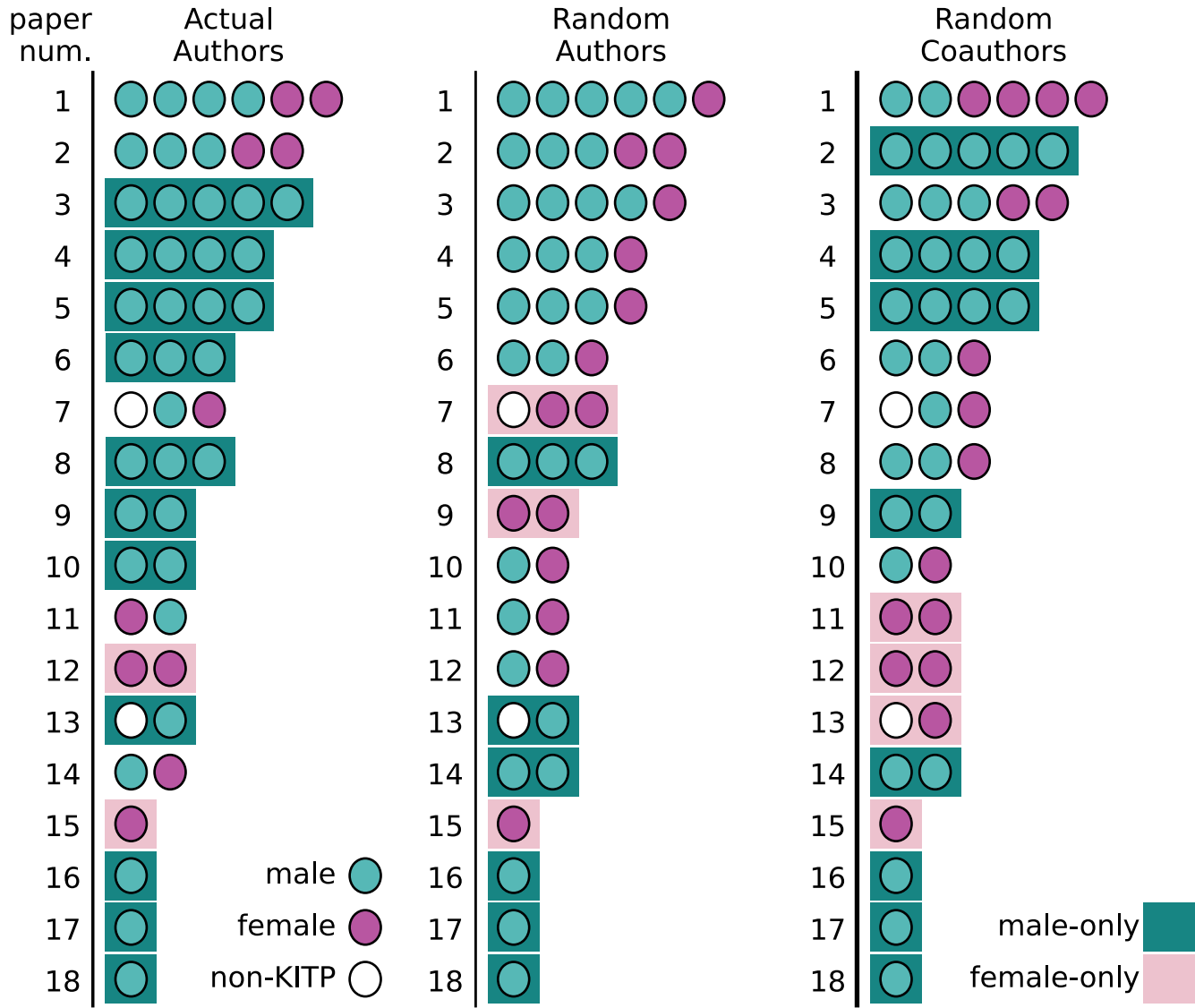
Figure 4. *Left:* The observed gender breakdown of authors on KITP papers. *Center:* One realization of the expected gender breakdown of authors on KITP papers if the KITP authors on each paper were drawn randomly from the participants. *Right:* One realization of the expected gender breakdown of coauthors on each paper was drawn randomly from the participants, with the observed genders of the first authors fixed. Blue circles indicate male authors, pink circles indicate female authors, blue bars indicate all-male KITP papers, pink bars indicate all-female KITP papers, and the two white circles that appear in every column represent the two KITP papers not led by a KITP author. We note again that any "all-male" or "all-female" KITP paper may have non-KITP authors of any gender; we assess KITP clustering only.

5. Conclusions and Discussion

Despite considerable effort on behalf of the Probes of Transport in Stars organizers (two of whom are authors on this manuscript) and the Kavli Institute for Theoretical Physics itself (see Section 2), neither equitable nor proportionate gender outcomes were achieved according to the metric of publishing. Even allowing for an over-representation of male first authors—which may occur naturally for a variety of reasons, including that men are over-represented in more advanced career stages and/or that men have, on average,

less competition for their mental resources—the number of all-male KITP papers is anomalously high. This result is very unlikely to have been observed in conditions that reflect, or mostly reflect, the assumptions of the ideal collaboration environment described in Section 4.

The presence of all-male clustering is strongly supported by the low likelihood ($p < 0.03$) of producing 11 male-only KITP papers given the program's gender distribution (Figure 3). While the number of female-led papers is too small to make quantitative arguments regarding, for example, bias against

women in lead authorship roles, the facts that (1) there are so few such papers, and (2) that the maximum number of coauthors on these papers is 1, are not inconsistent with a preference against female collaborators among men.

We suspect that the most likely cause of the over-representation of male authors is a preference among men for male collaborators. Other explanations are also possible, including those that intersect with or amplify the effects of male preference for male collaborators. For instance, women may have produced proportionally fewer lead-author publications due to unequal demands on their time: they may have had a greater need to devote their time at KITP to finishing existing projects, or perhaps they could not escape from non-work-related burdens and time constraints (e.g., childcare, pet care, household management) to the same extent as their male peers. It is also possible that women were disproportionately excluded —whether consciously or unconsciously by men, or by their own choice—from networking or social events. As social events in academic spaces are, by and large, *de facto* collaboration opportunities, one could imagine that self-segregation by gender socially could readily propagate into self-segregation by gender on academic projects. This social self-segregation could be particularly influential for determining coauthors, as it is not always necessary to make a significant contribution to a paper to be invited as a coauthor.

Yet another possibility is that there are preferences by gender regarding publication type. These data, measured at a relatively early time post-program, could be explained by, e.g., a preference among women for longer-term projects or a preference among men for faster publication timelines. We have not studied these possibilities here, as they require more longitudinal data, but future analysis may shed light on these hypotheses.

Though KITP provided a nearly obligation-free *scientific* and *working* environment to all, broader gender inequalities regarding free time, expected labor, mental availability, and social segregation may still have exerted influence. To mitigate the impacts of these and other well-documented productivity disadvantages affecting women requires thoughtful policy beyond "equal opportunity" or representative gender distributions on participants lists. Some actionable suggestions are given in the next section.

6. Suggestions for Improvement

It is often anecdotally observed that women and gender minorities are aware of gender bias and men are not. Regardless of the degree to which this is true in practice, the first step toward equitable outcomes is awareness of a lack of equality despite efforts to encourage it.

First, it is imperative that we re-assess gender outcomes from this workshop at later dates and at regular intervals. We suggest that the publication data sets should be reconstructed again in

six months (2022 December) and 12 months (2023 June) to see how trends evolve. It is especially important to learn whether the striking gender disparity in research output we see now lessens over time, though this will not affect conclusions drawn now, at the six-month stage.

We must also recognize that the strategies employed by KITP and the program's organizers were insufficient for preventing a high degree of gender clustering, especially among men. To this end, we offer some ideas for discouraging gender clustering, improving participant crosstalk, and avoiding the pitfalls of social dynamics that, intentionally or unintentionally, make women less likely to be included as collaborators. Though a specific KITP program was the context for this study, these suggestions apply to all programs and workshops.

Consider opening your program or workshop with a lecture on gender statistics to ensure that those who are not already aware of gender bias in publishing and collaborating are made aware, and consider reiterating this information at, for example, the start of each week.

Consider giving a short assessment to potential participants to learn whether they are aware of gender bias.

Consider how opportunities for self-segregation by gender could be limited; for example, by introducing structure around mealtimes.

Consider whether social events designed for academic purposes are taking place in gendered spaces,[9] such as bars, and whether collaboration opportunities are being scheduled at times where women proportionally have more home obligations (e.g., after standard working hours, on school nights, etc).

Consider incentivizing multi-gender collaboration with actions such as verbally surveying who worked with whom over a given time interval or otherwise measuring, monitoring, and drawing attention to the gender composition of breakout working groups throughout the program.

Work to ensure that men take on the same or greater amounts of organizational labor and non-science-related burdens while participating in a program; social science data show that women will tend to volunteer themselves for these obligations out of social conditioning, so it is best to assign non-science-related labor externally.

Strive to model gender inclusivity by publicizing inclusion as a "best practice" of the program environment and of science more broadly; for example, by stating that inclusive behavior is not only encouraged, but expected in your program

Consider devising a formal system for declaring and joining projects made possible by your program's resources, as is the norm, for example, in large observational collaborations.

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9   Spaces where members of one gender may feel more comfortable than members of another, or spaces where it is safer for one gender than another.

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Consider distributing reports like this one to participants prior to the program.

As physicists and astronomers, we are not trained, in a professional sense, to study gender bias. We have therefore tried to limit the complexity and causal analysis of our study to the most clear conclusions, namely that men are over-represented among first authors and that the data support a preference among men for male coauthors. Both of these conclusions are consistent with a variety of previous studies in a wide range of fields, from formal social science to other demographic studies within physics. However, we emphasize them here in the practice of modern astronomy, in hopes that our study can encourage future efforts to improve gender discrepancies in astronomy careers. While we do not expect the suggested mitigation strategies, even if perfectly executed, to guarantee equitable gender outcomes, we look forward to continued discussion and efforts to improve the state of our profession.

*Software:* NASA ADS, arXiv, Python: numpy, Python: matplotlib.

Appendix
Papers Included in this Analysis

We list each member of the data set on which the above statistics were calculated by arXiv identifier, given in Table 2. The papers classified as "KITP papers" are listed first and a total of 18. The remaining 76 papers are papers published between 2021 December 1 and 2022 June 3.

Table 2
Publications by arXiv ID

Index	arXiv ID	KITP?	Index	arXiv ID	KITP?	Index	arXiv ID	KITP?	Index	arXiv ID	KITP?
1	2206.00011	yes	25	2205.09655	no	49	2204.00661	no	73	2112.02026	no
2	2205.02251	yes	26	2205.08841	no	50	2203.15365	no	74	2201.04140	no
3	2202.10026	yes	27	2201.01722	no	51	2203.14538	no	75	2110.11974	no
4	2205.09903	yes	28	2205.09125	no	52	2203.15116	no	76	2201.00891	no
5	2205.03319	yes	29	2205.07964	no	53	2109.13840	no	77	2112.12800	no
6	2204.10875	yes	30	2205.07996	no	54	2203.11532	no	78	2112.12122	no
7	2204.08487	yes	31	2202.12902	no	55	2203.11809	no	79	2111.11552	no
8	2204.00002	yes	32	2202.07524	no	56	2203.11227	no	80	2111.14047	no
9	2203.11071	yes	33	2203.08920	no	57	2202.10507	no	81	2112.05964	no
10	2203.09525	yes	34	2205.03020	no	58	2110.11356	no	82	2111.11633	no
11	2203.06186	yes	35	2205.01860	no	59	2203.05463	no	83	2110.06220	no
12	2203.06187	yes	36	2205.02278	no	60	2203.04970	no	84	2110.01565	no
13	2203.02046	yes	37	2205.01798	no	61	2110.03261	no	85	2111.06434	no
14	2202.03440	yes	38	2205.01298	no	62	2202.12903	no	86	2111.06891	no
15	2111.01958	yes	39	2204.12643	no	63	2202.11080	no	87	2112.03306	no
16	2111.01959	yes	40	2202.02373	no	64	2202.08398	no	88	2112.01309	no
17	2201.10567	yes	41	2204.09739	no	65	2202.07811	no	89	1509.03630	no
18	2201.10519	yes	42	2204.10600	no	66	2201.12364	no	90	2102.09920	no
19	2206.00025	no	43	2204.08598	no	67	2202.04671	no	91	2106.05228	no
20	2205.14161	no	44	2204.09070	no	68	2201.02252	no	92	2106.07659	no
21	2205.12922	no	45	2201.11131	no	69	2111.01165	no	93	2012.10797	no
22	2205.11679	no	46	2204.06203	no	70	2111.04203	no	94	2110.14659	no
23	2205.11318	no	47	2204.06004	no	71	2201.08407	no			
24	2205.11536	no	48	2204.00847	no	72	2201.05359	no			

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