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comment

Diversity and inclusiveness in large scientific collaborations

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Considerable progress has been made in the past decade to increase diversity in astronomy, and in particular to reach a 'critical mass' of women. It is however important to realize that this progress has mainly been the result of the selective inclusion of women from more privileged backgrounds.

Modern astrophysics is characterized by collaborations of increasing size, which can bring together hundreds of scientists from tens of different countries and several different continents. This allows scientists to pool resources and expertise to effectively pursue more ambitious, costly and sometimes risky projects. Such large partnerships also pose new and unique challenges, not only for the scale of the scientific endeavour, but also in valuing and integrating the different cultures and backgrounds of the participating scientists.

Climate, inclusiveness and diversity are becoming topics of interest in science, technology, engineering and mathematics, motivating ongoing measures to promote diversity and reduce the effects of explicit and implicit bias (see, for example, ref. [1]), which have had varying degrees of success. Such initiatives are generally put in place at the institutional, national or funding-agency level. In contrast, modern large collaborations are confronted with a wide range of cultures and backgrounds when it comes to climate, inclusiveness and diversity. This presents a unique challenge that extends beyond the infrastructure of a single university, national professional society, funding agency or country regarding the responsibility to document problems or to devise and enforce solutions. It is therefore paramount in this collaborative environment to find effective approaches to identify concerns and then devise and implement measures and practices to address those concerns.

The Sloan Digital Sky Survey (SDSS), presently in its fourth generation (SDSS-IV)[2], is one of the largest international collaborations in astrophysics to date, presently counting over 700 active members, including scientific and technical personnel, postdoctoral researchers, students and educators distributed across more than 50 institutions in 18 different countries and four continents. In 2012, the Committee on the Participation of Women in SDSS and the Committee on the Participation of Minorities in SDSS were established, with the aim of examining and evaluating climate and diversity within the collaboration, devising measures aimed at their improvement, and advising and supporting the SDSS management in their implementation. These two committees merged in 2016 to form the Committee on Inclusiveness in SDSS.

To more effectively address these responsibilities, the Committee on the Participation of Women in SDSS and Committee on Inclusiveness in SDSS have been administering an annual, collaboration-wide, voluntary demographic survey. The American Astronomical Society[3] and the UK-based Royal Astronomical Society[4] have undertaken similar efforts. However, the SDSS demographic survey is the only one to date to take a snapshot of a large international astronomical collaboration, offering a unique perspective on this particular environment.

The first demographic survey, which was run in 2014, contained questions in the categories of 'career information', 'experience within the SDSS', 'leadership in the SDSS' and 'demographic information', including gender identity, race/ethnicity, geographical location and self-reported minority status[5]. The scope of the questions about demographic information has expanded in the 2015 and 2016 surveys to include information about partnership and family status, identification with the LGBTIQ+ (lesbian, gay, bisexual, transgender, intersex and questioning) community, disability status and parental education background. The questions about experience within the SDSS also now include specific questions about work environment climate. While considerations about the responses provided by members who self-identify as having a disability or as members of the LGBTIQ+ community would be of great interest, small-number statistics prevents us from drawing robust conclusions and we therefore refrain from discussing them further.

The response rate was high in all three annual surveys, ranging between 50% (2014) and 30% (2016), with several hundred members filling in the survey. The present discussion is based, however, on the data from 2014 and 2015. The data from the 2016 survey are still being analysed. Note also that, as the respondents to the survey are expected to be typically actively involved in the collaboration, the results will likely be biased towards those who already hold leadership positions. The majority of the respondents were affiliated with institutions based in North America and Europe, with two-thirds of the sample being made up of faculty members or research scientists and one-third of postdoctoral researchers and graduate students. Women are about one-quarter of the respondents, both in the overall sample and in the self-reported leaders, which is consistent with the fraction in the US astronomical community[3] and considerably higher than that in the International Astronomical Union, which is only 17% (http://go.nature.com/2qVqVmI). In addition, about 15% of the respondents self-identified as a member of a minority group in their home institution, with a marginally lower share among the leadership. While the International Astronomical Union does not keep official statistics regarding members belonging to minority groups, the 2013 American Astronomical Society demographic survey showed that non-white respondents made up 14% of the sample.

In the context of analysing these data, it is important to recognize that the women in the SDSS collaboration and in the field of astronomy in general are dominated by women from majority racial

and ethnic groups (for example, white women in the United States) and from privileged backgrounds in terms of parental educational achievement. Furthermore, the scientists who identify as first-generation college students and/or as racial or ethnic minorities at their current institutions are predominantly men. From that perspective, the results of the SDSS demographic survey do not necessarily reflect the experiences of women from minority groups, and this speaks to the importance of ongoing work on the intersectionality of marginalized identities and its clear impact in astronomy (for example, see the Perspective on this topic in this issue[6]).

While the overall statistics indicate that the SDSS has been quite successful in recruiting a leadership representative of the overall population from which it is drawing, in terms of these broad demographic categories, there is evidence that women and minorities face additional challenges in developing their careers and reaching leadership positions. One cause for concern is that among leadership positions that were filled by members who joined the collaboration more recently (that is, scientists who had not been part of the SDSS-III survey), a disproportionate fraction of the leaders are men (over 90%), regardless of career stage. While bias may play a role in the selection of scientists for leadership positions, selection committees and senior colleagues have anecdotally reported reluctance from women to apply for leadership positions at the same rate as men. Moreover, the demographic survey data indicate that even when they do assume leadership responsibilities in SDSS, women and minority members are less likely to have their roles officially recognized with named leadership positions.

A possible interpretation is that the taking on of the responsibilities and commitments related to these positions is not perceived as feasible or worthwhile by women scientists. Especially since they are also more likely than their male colleagues to be already over-committed with service duties, which do not however carry much weight when considering criteria for promotion[7].

One important result regarding family education background is that women are only half as likely as men to be first-generation college students, while scientists from minority groups are nearly twice as likely as those from majority groups to be first-generation college students. Overall, nearly one-quarter of survey respondents were first-generation college students, half have at least one parent with an advanced degree (master's, professional or doctorate), and approximately one in five have a parent who completed a PhD. High family education attainment is common in academia: second- (or third-) generation college graduates are four times more likely than first-generation college graduates to receive a PhD[8], which is generally necessary to pursue an academic career. That said, it is worthwhile to consider how such a selection effect for professional astronomers in terms of parental education is stronger for women than men. What does that imply about the barriers faced by women when entering the field of astronomy? For example, approximately 13% of women who responded to the survey are first-generation college students, compared with 27% among men, and 55% of women have a parent with an advanced degree, compared with 40%

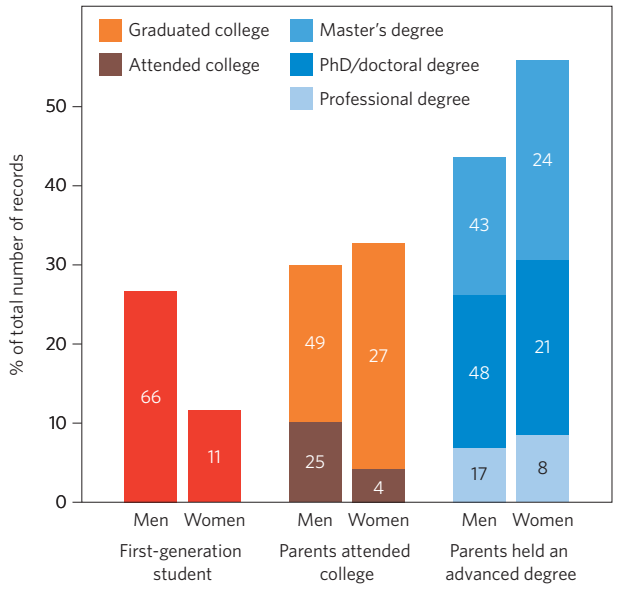

Figure 1 | Highest education level completed by parent or guardian for members of the SDSS collaboration self-identifying as men and for those self-identifying as women. Digits in the histogram boxes are numbers of respondents.

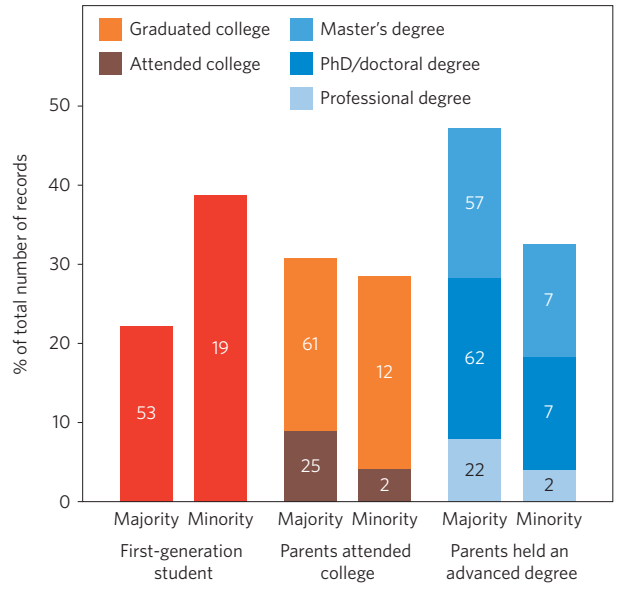

Figure 2 | Highest education level completed by parent or guardian for individuals of the SDSS collaboration self-identifying as members of a racial or ethnic majority and for those self-identifying as members of a racial or ethnic minority in their institution. The total number of responses reported in this figure (329) is different from that in Fig. 1 (343) as some respondents opted to not answer some of the questions.

among men (Fig. 1). In contrast, among minority scientists the fraction of first-generation college students is much higher (40%) and the fraction with parents having advanced degrees is lower (33%), as shown in Fig. 2.

Interestingly, most of the survey respondents indicated that they agreed (or strongly agreed) with the statement that the collaboration fosters an inclusive climate. But even in this case, the responses are quite different among different members of the collaboration. For example, those who are in leadership positions, men and respondents from majority racial or ethnic groups were much more likely than their counterparts to view the climate of the collaboration in a positive manner. In particular, leaders were three times more likely than non-leaders to agree with the inclusiveness statement. While not unexpected, this result shows evidence of confirmation bias[9] conveying how those with privileged status are more inclined to think that the environment in which they succeed is fair and equitable.

Improvement with respect to diversity and inclusion has been on the agenda of the collaboration leadership for some time. Specific US-based initiatives, supported by the Sloan Foundation, have been put in place in the past several years to increase the participation of minorities in the collaboration and to provide mentorship for research students from underprivileged backgrounds. There have also been efforts to make information about the survey more accessible in general to new collaboration members. In the context of these ongoing effects, continued monitoring of the collaboration through the yearly demographic surveys will be able to track the progress and success of these programmes. But one thing remains clear: the inclusion of women in astronomy has thus far been a selective inclusion of women from privileged backgrounds in terms of race, ethnicity and parental education. We must do better.

And as many SDSS members progress in their careers, move to different institutions, join other collaborations and forge ties to new groups, we hope that they will take along the culture of self-reflection, internal enforcement of fair practices, and promotion of inclusiveness and diversity that the collaboration has been spearheading in the past several years. ❐

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