

Investigating experiences of a Black woman in physics and astronomy

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This research focuses on the experiences of physics and astronomy graduate women of color. We conducted semi-structured, empathetic interviews to understand their experiences in their graduate program and how they navigate the physics department at a large research university, which is a predominantly white institution. The interviews are guided by critical race theory (CRT). We use CRT to examine how racial identities play a role in the obstacles faced by these women, including interactions with peers and faculty members. In this paper, we focus on the experiences of a Black woman in physics, Linda, to understand how her marginalized identities affected her experiences in physics during her undergraduate and graduate programs. The themes that emerged from Linda's interview include lack of support, more than just doing physics, and persistence in physics.

I. INTRODUCTION

In the U.S., women of color (WOC), who identify as Black, Hispanic or Latina, American Indian, Alaska Native, Asian American, Pacific Islander, Native Hawaiian, or mixed have been historically underrepresented and excluded in physics. Representation amongst WOC in physics has not changed drastically enough to reflect racial equity. For instance, between 2006 and 2016, 4% of physics bachelor's degrees were awarded to WOC, not including international students [1, 2]. Also, out of all physics Ph.D. degrees awarded to women, 2.9% were earned by underrepresented minority women, i.e. Black, Hispanic or Latina, and American Indian women, between 1974-2006 [3]. More recently, between 2014-2019, this number has remained consistent [4].

However, these numbers have not changed drastically and do not accurately reflect the US population [5]. Although many institutions have committed to becoming more inclusive either by means of increasing enrollment, creating diversity statements, etc., these are not sufficient to dismantle larger systems that continue to uphold racial hierarchies and exclude students with diverse identities [6]. In addition, social cultures in STEM, e.g., physics, are notorious for fostering environments that uphold racism and sexism [7–11]. It is crucial to understand how they continue to exclude and have negative impacts on women of color.

At predominantly white institutions, PWIs, women of color are further minoritized by their gender and racial identities. These spaces are essential to study because they tend to graduate more women of color, compared to minority serving institutions and women of color are more likely to feel isolated and not have sufficient support systems [2, 12–14]. It can be argued that social change and social equity at these institutions occur more slowly relative to institutions with larger percentages of people of color.

In addition to low representation amongst women of color, few are able to express their truths and experiences potentially due to reasons such as toxic social cultures, lack of support, lack of mentors, low visibility, and tolls on their well-being [15, 16]. Interviews are able to create a safe space for minoritized students to express their experiences and connect them to larger structures present in their field, such as racism and sexism [17–21]. Interviews from women of color also serve as counter stories, one tenant of Critical Race Theory (CRT). We use CRT as a framework to understand how racism is ordinary and universal, even within physics, and how it affects the experiences of women of color [22, 23].

II. METHODOLOGY

We conducted semi-structured empathetic interviews with 4 graduate women of color in physics and astronomy at a large PWI. This is important to mention since these women are minoritized not only by their gender but also by their race and ethnicity. These women volunteered after multiple adver-

tisements sent through department email lists. In this paper, we analyze one of the four interviews. The interviews took 1.5-2 hours and each student received a \$25 compensation for participation. Protocol questions were adopted from a previous study [24] and refined by researchers before conducting interviews. The questions probed women's racial identities in relation to their experiences in physics and astronomy.

We chose these interviews to be semi-structured in order to learn about each woman's journey in physics and astronomy. Because each woman of color is unique, some of the questions we asked pertained only to those women specifically, although we attempted to maintain consistency by asking these women the same overarching questions about their race in relation to their experiences in physics and astronomy. We chose to conduct empathetic interviews in order for women to express themselves comfortably [25] such that we are able to have a better understanding of their experiences in their graduate program. The interview that we analyzed was coded using inductive coding methods in order to take a holistic approach and to avoid overgeneralizing the experiences of women with different racial identities [26]. For this reason, we focus on Linda (pseudonym), a Black queer woman to share how multiple aspects of her identity affect her experiences. Although Linda identifies as a queer woman, here we do not address how her queer identity influences her experiences in physics and astronomy.

A. Positionality statement

One researcher, who interviewed the women of color and coded the transcripts through multiple rounds, identifies as a Latina-American queer woman, while the second researcher, who collaborated on coding, identifies as a woman of color. These identities can play an essential role in creating a safe environment for these women to express themselves freely in the interviews as well as understanding their experiences, as some of their struggles were relatable to the researchers.

B. Linda, a Black woman

In this section, we introduce Linda, a Black woman enrolled in a Ph.D. program in astronomy at a large PWI. She graduated from a small liberal arts PWI with a bachelor's degree in physics and astronomy. It is also important to note that Linda was the first Black student to graduate from her undergraduate institution with a bachelor's degree in physics and astronomy. At the time of the interview, Linda was in her second semester of her second year in her graduate program in astronomy. While deciding on which graduate program to enroll in, she was informed that her current program had not successfully awarded a Ph.D. to a Black woman.

We discuss how systemic racism affects her experiences during her undergraduate and graduate program.

III. RESULTS AND DISCUSSION

The codes relate to our CRT framework, by describing how institutions foster racist beliefs and affect students with multiple marginalized identities. Using tenants of CRT (permanence of racism and counterstorytelling), we developed the following main themes:

AT1. Lack of support

AT2. More than just learning physics

AT3. Persistence in physics

A. Lack of support

Throughout her interview, Linda mentioned many instances during her time at her undergraduate institution when she felt that she did not belong in physics, especially while interacting with her physics peers. Examples of these incidents included when Linda acknowledged that she was one of four Black women in her classes. She also described that her Black peers were not supported and as a result, “none of them actually made it through the program.” Linda elaborated that she was the only Black student from her undergraduate institution to graduate with a bachelor’s degree in physics and astronomy in the spring of 2020. This in combination with how peers judged her for lack of familiarity with physics shows how structural issues such as racism exclude Black students from participation in physics.

She felt that her undergraduate institution lacked efforts to support students of color and also the culture and attitudes of many faculty were not inclusive towards supporting students of color in physics. She said, “...they just didn’t seem to care about like their... black and brown students. Like the majority of [students I interacted with, including myself]... could pinpoint a moment in time, specifically where... a professor said, *Hey, go try something else*, or, *Are you sure you want to do this?*” Previous research has shown that comments and attitudes such as these are common in excluding Black women in STEM [10, 11, 27].

1. Lack of belonging

With regards to lack of support, Linda described a moment when she expressed her lack of belonging in physics. During her junior year of undergraduate program, Linda made a poster, for her printmaking class, which she posted around campus. In the message in her poster, she criticized physics instructors in whose classes she experienced lack of representation and support. She made comments such as:

How can you claim to observe the natural world without seeing who is missing from your classroom? Science may try to be objective, but you are not. Recognize your bias.

Linda elaborated on this experience and described how a physics professor responded to her poster, “he printed out a piece of paper with a response to it and like taped it [onto

the poster]... And then, when I took [his response] down...he added like 20 more thumb tacks and reprinted it.” Here we see how Linda’s poster caught the attention of one physics professor. She even shared that this particular professor posted defensive responses such as, *It seems harsh that you question my powers of observation. Will you not come to observe my class?* Linda said that this professor was ignorant in that he assumed that such a comment was made by someone who had not been in his class, and had not experienced such isolation, “making the assumption that I haven’t been in his classroom to begin with.” Linda perceived that this professor’s comments were defensive and more concerned with vandalism rather than systemic change in supporting the few students of color in the department, who also experienced isolation and exclusion in physics. It is also possible that the professor was concerned about the department or institution’s reputation, as Linda explained that her institution offered her financial support to recruit more students of color.

B. More than just learning physics

Whenever she entered a physics classroom, Linda was constantly hyper-aware of herself and any potential stereotypes her peers might associate her with. In her undergraduate courses, she said that when she entered a classroom, “...I would analyze the social situation first and there would be definitely feelings of like isolation, like [lack of] belongingness, and then I would have to sit down and then like learn physics.” Being inside of a physics classroom was more than about learning physics, she had to use extra cognitive resources to remain aware of her identity relative to other peers.

1. Hyper-visibility and invisibility

Being one of the only Black women in her classrooms, Linda felt like she did not belong in physics. It seemed as though the physics culture did not accept her Black identity. Specifically, Linda pointed out that she was conscious of her physical appearance. She said that she avoided wearing certain accessories to conceal her Blackness, “I wouldn’t wear a headscarf to class, which, I mean, is like pretty normal for like Black women to do, but I wouldn’t wear one.” As an attempt to not emphasize her Blackness, she resorted to suppressing elements of her culture. She explained her reason for doing so, “I guess I just won’t wear a headscarf because I don’t want to be more “othered” than I already am.” To summarize how she felt, she said, “I felt both invisible and hyper-visible in the classroom.”

When asked about if her sentiment was different pertaining to graduate school, Linda said that her experiences throughout college drove her to acclimate, “... I’ve had four years of conditioning to get used to it... I have had experience in trying to learn how to adapt in those types of situations... and I remember where I’m at and who I’m surrounded by but I’ve had

some time to build a loose tunnel vision between me and the teacher, where I kind of forget the other people in the room, so personally I like to sit... either in the front, where I can't see anybody behind me or on the side by the sun, where I can see outside the window." Unfortunately, Linda was forced to adapt through many years of experiences with analyzing social environments in the physics classroom. The whiteness of physics classrooms made her feel isolated and that her Black identity did not belong.

2. Awareness of stereotypes

Following Linda's experience in which she posted a poster expressing how she felt that she did not belong in physics, she sent an email to schedule time to talk to that undergraduate professor. During that interaction, she said, "[I was] obviously, very diplomatic because I'm not allowed to show anger." Although this was the first time Linda explicitly made this comment, this is not the only experience in which she was aware of stereotypes against Black women in particular.

She also explained that because of her lack of familiarity with physics, i.e., she did not take any physics courses during high school, she was not comfortable speaking up in the classroom, and as a result, she avoided asking questions. In combination with her lack of comfort talking about physics, her race also affected her participation, "I didn't really like to ask questions [for] a long time cuz I didn't want to be perceived as like dumb or if I asked a dumb question... it didn't feel like I was just answering the question, it felt like I was answering the question for my whole race." We also suggest that the lack of representation in her program contributed to Linda's awareness of stereotypes about Black people. She reiterated, "if I ask a dumb freaking question, then they're going to continue to assume that Black people are dumb and based off of their interactions with me, I would say that that's already a subtle thought that they probably already had." Linda's awareness of potential stereotypes held by her peers also provide evidence for how racism manifests in combination with being isolated in her program.

Not only did Linda have to use cognitive resources to actively remain aware of stereotypes during her undergraduate program, but also during her graduate program. In the process of communicating with instructors, Linda was often cautious about sending carefully-worded emails. She explained her reason which was, "I have to frame just general things that... if a white person said this to them, they probably wouldn't take it that way, but I have to put like a little disclaimer in the email that says, *Hi, this message is not intended to be aggressive, to harm your feelings... [or] not intended to hurt you or come out as aggressive in any shape or form.*" She was forced to frame her emails in such a way to eliminate any possibility of instructors forming negative stereotypes about her. She also suggested by being hyper-conscious of how her messages are interpreted across emails, that she could not express what she intended to because of her racial identity, "... [the

emails] are very strategically developed because, if I were to actually come out and say... what was in my head, then they would take that as being overly aggressive because I am a Black person, they would assume-they immediately put me in the role of angry Black woman and then they would disregard the actual issues..." Linda's experiences of feeling negatively stereotyped demonstrate the permanence of racist beliefs.

3. Tolls on well-being

Linda said that during her undergraduate program, her mental health was effected negatively. She developed anxiety during her sophomore year in college because she began to envision her future career if she continued to pursue physics in academia: "I realized that I'd probably be like pretty alone, like physically, like when I look around the room, it probably would just be me as the only melanin there." Unfortunately, this thought remained even during graduate school especially due to the fact that both institutions are PWIs and representation for women of color, and especially Black women, remains low. Developing anxiety was a direct consequence of continuing in a field that historically excluded women of color.

She also shared that this unfortunate realization of experiencing additional isolation and lack of representation, "... really creeped me out and that, you know, fear of being alone, fear of that isolation starts [to] like kick up, and so did my anxiety... and then, at some point, you know, there was like depression, which is exhausting." For Linda, she might have developed trauma by being one of the only Black women in her department, being subjected to isolation, stereotypes, and suppression of her identity. She directly connected the tolls that she experienced on her mental and emotional health as being caused by how her peers perceived her, "... the way that I was perceived in [my] undergraduate, in general, definitely had an effect on-how tired I was, and that was just like a daily occurrence."

When asked about her experiences in graduate school and lack of mentors and role models both in her department and in her prospective field, cosmology, Linda explained how exhausting it is for her. She said, "I think that I just get tired [a] lot more easily than like my peers because... I try and keep a lot of, you know, positive energy, because if I don't... I just like explode, but I think that a lot of it is pretty exhausting to know... that you're doing something that is-just hasn't really been done by that many people and like there's definitely a sense of like loneliness in doing that... and I don't think that that is necessarily appreciated." In her perspective, the additional tolls of being a woman of color were caused by loneliness and affect both her cognitive load and her energy. Physics departments are not cognizant of these and thus can lead to women of color, such as Linda, to feel underappreciated and invalidated [28].

C. Persistence in physics

1. Support and validation

Although Linda was subjected to stereotypes throughout her experiences in physics, she was able to persist during her undergraduate career and currently in her graduate program. She credited her persistence to various support groups that she formed, which have mainly been composed of people of color or women.

Her support groups during college included students from other majors who, she said, allowed her to, "... take apart, whatever kind of crap I was experiencing in the classroom and be like, *Okay, this is insane, thank you for validating the fact that this is insane...*" It is in these spaces where Linda found validation in her experiences and was able to come to terms that external systems, such as racism, are the cause for her negative experiences.

During her first year in her graduate program, she connected with other Black graduate women at her institution, whom she found very supportive: "... I find that that is very helpful for me to see other people who look like me and no, we're not doing the same thing, but it's like a breath of like fresh air being able to feel, like safe around them." She also explained that having this support system of other Black women is essential for her because, "I don't have to explain the multi[ple] layers that are present there. It's just kind of like, *Oh, you get it, awesome....* that in and of itself is validating because you know that you are not the only one going through this you know difficult problem." Allowing women of color, such as Linda, opportunity to make these bonds is critical since women of color are often isolated, especially at PWIs [29, 30].

2. White shields

Linda expressed gratitude towards a white female peer in her cohort who has been a major source of support for her. For example, this peer accompanied Linda to discuss some of her negative experiences to the departmental chairperson. She said, "... one thing that actually very much helped me... was having like a white person also go with me... so I didn't have to sit there and emotionally exhausted myself." Not only did her peer emotionally support her by listening to her experiences and validating them, but also by offering to "shield" Linda from reliving those experiences when she discussed them with other faculty.

She acknowledged the white privilege held by her peer. Linda elaborated that because of her peer's white identity, "[she] had some sort of privilege...so that they weren't just like: *Oh, the black kid [i]s bothered again.*" She implied that if she were to express her concerns, departmental members would not take her seriously. Linda's experience illustrate how white allies and shields can be essential in dismantling

racism and using their privilege to make other white people believe experiences of women of color [31–34].

IV. LESSONS LEARNED FROM LINDA'S EXPERIENCE

Although the existence of stereotypes had a large impact on Linda and her experiences in physics, we discuss some lessons learned and suggestions to implement.

Cognizance of implicit biases and stereotypes: Throughout Linda's physics career, she battled stereotypes which ultimately dictated how she felt perceived and how she behaved. Although stereotypes are difficult to dismantle, physicists should be aware of the biases they hold and how they can exclude WOC.

Check-in with students of color: Linda expressed various moments of isolation, during her undergraduate and graduate programs. We suggest members of the physics community to consistently check on students of color, especially women of color who might be especially isolated. This can be done through mentoring programs, assigned advisors, etc.

Creating communities of and for women of color: Linda's experiences have shown how forming communities of color allows for validation. These are essential, especially within PWIs, where students of color can be more segmented. Funds can encourage the formation of these communities, e.g., student of color dinners or WOC groups.

Not combining clubs with multiple identities: There should be caution when forming affinity groups with multiple identities. For instance, whiteness may dominate various spaces such as women in physics groups. It may be beneficial to have separate spaces for WOC.

V. CONCLUSIONS

Linda's experiences of her physics career provide insight to how her marginalized racial identity has affected how she navigates physics and her interactions with members of the physics community. Due to her racial identity and stereotypes associated with it as well as lack of representation, she has felt marginalized consistently throughout her physics career. Although this is a brief insight into Linda's experiences, they illustrate the negative consequences on her mental and emotional well-being. As researchers and members of the physics community, it is our responsibility to support students who are especially minoritized, such as Linda. In doing so, we need to work together to dismantle discriminatory systems, that are not specific to physics, but extremely detrimental in spaces that do not reflect identities of the general population (e.g., racial minorities). Through Linda's experience, she shows how white allies can act as white shields and dismantle racism from inside, rather than placing the responsibility on people of color.

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