Certain bodies in uncertain fields: Thinking about gender through queer theory and quantum mechanics

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This paper explores the potential for marginalized perspectives to deepen our understanding of complex phenomena in quantum theory. Grounded in Standpoint Theory and Intersectionality, it analyzes how marginalized identities offer unique epistemological advantages that challenge traditional narratives. Drawing parallels between classical and quantum physics and theories in gender and identity, this paper examines the ontological frameworks within each domain. Classical physics, characterized by determinism, mirrors biological determinism in gender studies, while quantum physics introduces probabilistic elements similar to Butler's performance theory of gender. By embracing the fluidity and complexity of identity, this paper challenges rigid conceptions to foster inclusivity in the production of knowledge. This study underscores the importance of integrating diverse perspectives in physics and physics education.

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I. INTRODUCTION & BACKGROUND

Physics education research (PER) has begun to incorporate ideas, philosophies, and research from our colleagues in the humanities and from scholars focused on critical studies [1–5]. Very few peer-reviewed studies in PER have focused on the LGBTQ+ (lesbian, gay, bisexual, transgender, queer, and other identities) community, and almost none have incorporated ideas from queer theory to date [6]. This paper explores the parallels between queer identities (non-normative gender and sexual identities) and quantum theory through the lenses of Standpoint Theory and Performance Theory. It examines how the fluidity, complexity, and intersections of queer identities align with the principles of uncertainty and superposition in quantum theory.

A. Queer as an identity and a theory

Queer, as an identity category, has oscillated between a pejorative and accepted term over the last century [7, 8]. The term first appeared in the late 19th century in discussions of author Oscar Wilde [7]. By the early 20th century, queer was an identity label adopted by men who have relationships with men before being replaced by the term gay by the middle of the century. At this point, it was largely considered a pejorative until it was reclaimed as a radical resistance to the AIDS pandemic in the 1980s [9]. The term "queer theory" then began to coalesce literature on gender, identity, power, and sexuality from Michel Foucault to Gloria Anzaldúa and Eve Sedgwick [10–12]. Queer theory is an intellectual and critical framework that challenges and deconstructs traditional notions of gender and sexuality [13]. It aims to question and dismantle the binary understanding of these concepts (i.e., male/female, heterosexual/homosexual). Today, queer theory has expanded to include critical conversations at the intersection of race and other identities [14, 15].

B. LGBTQ+ literature in PER

The most comprehensive study on LGBTQ+ physicists derives from the 2016 American Physical Society LGBT Climate in Physics survey and the subsequent peer-reviewed publications released in the early 2020s [16–19]. This work revealed a concerning tapestry of climate experiences for LGBT (the term used at the time) physicists. Although 22% of the 324 survey respondents reported experiencing harassment or exclusionary behavior (EB), gender differences were apparent. Women in the sample reported a rate of harassment or EB of 31%, while transgender respondents reported a rate of nearly 50%. In line with the article by Cochran et al. (2024), identity had to be explored at multiple intersections [5]. In this study, race was also a complicating factor, with People of Color reporting being less out about their identities than their peers and describing instances of racism in both the open-ended responses and the focused set of interviews [16]. These studies demonstrate an exclusionary culture within physics [20].

One of the most powerful findings of the LGBT Climate in Physics Survey was the importance of inclusion [17]. Barthelemy et al. (2022) showed through regression modeling that inclusion was a stronger predictor of participants not considering leaving their institutions than exclusion was of predicting consideration to leave. This suggests that identity neutrality is not enough; physics needs to be actively inclusive to keep people in, and thriving, within the community.

This, however, is a fraught and challenging conclusion for many PER scholars who now live in states that have passed bans on diversity, equity, and inclusion (DEI) efforts [21]. Such bans go beyond their own legislative words and cause a chilling effect on campuses. From the experiences of the authors of this paper, in a state where DEI has been banned, any DEI efforts are now met with resistance and administrative efforts to silence critical scholars. The debate as to whether administrators want to crack down on DEI or are being forced by legislators is ongoing.

C. PER and queer theory

By juxtaposing PER with queer theory, which on the surface appear different, we can begin to see the intersections of both physical and social theories. This article brings together the duality of classical and quantum physics taught early in physics education with the often discussed but poorly understood theories of gender and identity that are canonical to gender and queer theory [9, 22–24]. To begin this conversation, it is important to understand *Standpoint Theory* and *Intersectionality*, theories previously discussed in PER, before turning attention to the similarities within classical and quantum physics education.

Throughout this paper, *ontology* and *epistemology* will be discussed, which is important to note before our conversation on Standpoint Theory. Ontology is concerned with the nature of existence and the fundamental categories that structure our understanding of the world [25]. In other words, ontology involves the mental models we apply to understand our physical world [26]. Through ontological frameworks, one can ask questions such as, "What is the true nature of the universe?" Epistemology, on the other hand, is concerned with the nature of knowledge [26]. Epistemology explores the methods used to acquire knowledge and the criteria used to evaluate what counts as knowledge [25]. Through epistemology, one can ask questions such as, "What is knowledge and how is it acquired?"

Standpoint Theories propose that individuals' perspectives and understandings of the world are shaped by their unique experiences and social positions, emphasizing the epistemological advantage of "situated knowers" [2, 27]. Originating from Marxist Standpoint Theory, which posited that the proletariat possessed a deeper understanding of capitalist society than the capitalists themselves [27], Standpoint Theories have since been further developed and applied across various contexts. Feminist Standpoint Theory, championed by scholars like Harding and Haraway, extended this framework to argue that women, due to their marginalized social position, inherently possess a more nuanced understanding of social phenomena [27–29]. Feminist Standpoint Theory has been used in PER since 2016 when Barthelemy and McCormick released a series of papers discussing the experiences of women in graduate physics and astronomy programs from their standpoints alone [1, 2, 30–34].

Intersectionality, a framework introduced by Crenshaw, expands upon Standpoint Theory by recognizing the complexity and intersections of individuals' identities [35]. Within the framework, individuals occupy multiple social positions simultaneously; some of these social positions may confer privilege while others subject them to oppression within society [36]. Analogous to particles in a superposition state, individuals can simultaneously embody both privileged and marginalized identities, shaping their experiences and perspectives in complex and unique ways. Scholars like Collins have integrated Intersectionality with Feminist Standpoint Theory, acknowledging that the epistemic advantage afforded by marginalized identities is not uniform and may vary depending on the intersectional dynamics at play.

As an epistemological framework, Standpoint Theory contends that knowledge is socially situated and emerges from the lived experiences of individuals within specific social contexts. Within domains of knowledge, marginalized identities often possess an epistemic advantage, offering unique insights and perspectives that challenge dominant narratives [2, 27, 29].

II. ONTOLOGICAL FRAMEWORKS WITHIN PHYSICS

Physicists and physics educators often do not critically examine their own epistemological and ontological assumptions when teaching core concepts within the field of physics [26]. However, inherently, physicists must navigate two distinct ontological domains: classical physics and quantum physics. In classical physics, which encompasses classical mechanics and classical electrodynamics, a positivist or realist ontology prevails [26]. In other words, classical physics has a worldview that there is an objective truth to reality that exists independently of the observer. Within this domain, the universe is viewed as deterministic, with all physical properties of a system are simultaneously definable, allowing for accurate predictions of future states. For example, in classical mechanics, objects treated as a point particle have trajectories that can be mapped, requiring knowledge of their current and future values for position and momentum. Similarly, within classical electrodynamics, the exact position and momentum of a particle can be simultaneously known and predicted for future times [26].

Conversely, in the realm of quantum mechanics, a probabilistic ontology is essential [26]. Quantum mechanics challenges the deterministic worldview of classical physics, introducing concepts such as wave-particle duality and the Heisenberg uncertainty principle. The Heisenberg uncertainty principle is described by the equation:

$$\Delta x \Delta p \geq \frac{h}{4\pi} \tag{1}$$

Where h is Planck's constant. This equation asserts that there exists a restriction on the precision with which position (x) and momentum (p) can be simultaneously known. Essentially, when one property is measured with greater accuracy, the precision of the measurement for the other property decreases [37].

The Heisenberg uncertainty principle reveals that in quantum mechanics particles such as electrons and photons exhibit both particle-like and wave-like behavior, depending on the context of observation. For instance, while these particles can be described using a particle model when interacting with a detector, they should be conceptualized as delocalized waves when propagating through space. This leads to our inability to precisely measure both position and momentum simultaneously [26].

The ontological shift between classical and quantum physics is exemplified by question number 41 of the Colorado Learning Attitudes about Science Survey (CLASS), which asks if it is possible for physicists to carefully perform the same experiment and obtain two different results [38]. Depending on the ontological framework employed, classical or quantum, physicists may interpret the question differently. In a classical ontology, this question would typically be deemed false, whereas in a quantum ontology, characterized by inherent probabilism, the question is deemed true [26]. A study done by Baily and Finkelstein (2009) used an amended version of the CLASS to characterize students' ontological commitments over the course of an introductory physics course sequence [26]. This study found that students often displayed a realist ontology in quantum-mechanical contexts even after instruction in modern physics. However, this was significantly influenced by instruction. When the instructor explicitly addressed ontological perspectives, students were able to adopt a quantum ontology. Conversely, when ontology was not addressed in the course, students reverted to a realist interpretation. Furthermore, students did not employ their ontologies consistently, often reverting to a realist perspective if the instructor did not address ontology in the given context (e.g., ontology was addressed in the double-slit experiment context but not in the hydrogen atom context).

This ontological duality within physics underscores the complexity and multifaceted nature of our understanding of the physical world. Just as physicists must navigate between classical and quantum frameworks, individuals grappling with the complexities of their multifaceted identities must navigate shifting societal norms and understandings. This highlights parallels between the ontological frameworks within physics and the complexities of human identity.

III. EXPLORING THE EPISTEMOLOGICAL ADVANTAGE OF QUEER IDENTITIES IN UNDERSTANDING QUANTUM THEORY

One facet of a person's identity is their gender, which may offer an epistemic advantage in certain domains. Before delving deeper, it is important to establish the terminology that will be used. Sex will be referred to as a person's biological and physiological characteristics, typically assigned at birth as male, female, or intersex [39]. Gender, on the other hand, refers to as a person's perceived or internal perception of their identity, which may or may not align with their biological sex [39].

Two contrasting ontological assumptions about gender are biological determinism and Butler's performance theory [39, 40]. Biological determinism considers gender to be a given characteristic assigned at birth, asserting that males are inherently men and females are inherently women [39]. Conversely, Butler's performance theory views gender as a social construct, created through the way we perform or enact our gender identity, rather than being a predetermined state [40]. Gender can be performed through dress, speech, jobs, passions and many other avenues.

The parallels between these ontologies and those employed in physics are noteworthy. Positivism is utilized in classical physics and biological determinism, while superpositions and uncertainty are central to both quantum physics and performance theory. Just as the measurement of a particle collapses its superpositon when measured using classical instruments, an aspect of an individual's gender identity collapses into the binary of masculine or feminine traits when viewed through a biological determinism lens. Within the framework of positivism within classical physics, when a ball is thrown, given the initial conditions, the entire trajectory of the ball can be determined. This is analogous to the positivism within biological determinism, where a person's gender identity is considered predetermined at birth or even before birth through the use of an ultrasound. Conversely, in the uncertain lens of quantum physics, until measured through experiment, a particle exists in a superposition of both spin-up and spin-down states. This is analogous to performance theory, where a person's gender identity exists in a superposition of masculine and feminine traits.

Through the concepts of entanglement and non-locality, traditional linear models of identity formation can be challenged. The quantum phenomenon of entanglement occurs when the states of two or more particles become correlated in such a way that the state of a particle instantly influences the state of another, regardless of the spacial distance between them [37]. This phenomenon introduces the concept of non-locality, since the ability of particles to instantaneously influence each other's properties regardless of distance violates the classical notions of causality and locality [37]. Traditional frameworks in gender identity, such as biological determinism, rely on linear, casual explanations. For example, these frameworks believe that gender is determined by biological factors, such as chromosomes or hormonal patterns. However, just as quantum phenomena like entanglement and non-locality challenge our classical understanding of causality and locality in physics, they can also challenge our understanding of the interconnectedness of gender and identity.

Consider the concept of entanglement in the context of performance theory. Just as entangled particles exhibit correlations that transcend spatial separation, individuals' identities can be entangled with each other in complex ways that transcend conventional categories. This suggests that one's gender identity might not be isolated or independent but rather intertwined with and influenced by the identities of others. For example, Cech and Waidzuna found that the stereotypes associated with being a queer woman provided them with greater credibility and respect in STEM environments [13, 42]. This study found that queer women were often viewed as more "competent" due to the assumption of having adopted masculine traits.

In the words of drag queen Glamrou (off stage known as Amrou Al-Kadhi), "Quantum physics is to Newtonian physics what queer theory is to heteronormativity" [41]. Glamrou's perspective on their gender identity finds resonance with quantum theory: "It gives me immense hope that there's this model of the world, this real physical, philosophical model, which shows us that reality is just a set of contradictions with no real fixed foundation . . . It is in this model of space-time as a series of entanglements that I am able to piece together all the fragmented sects of my identity" [41]. Considering Glamrou's account of locating their own identity within quantum theory, one must wonder if there is exists an epistemological advantage to identifying outside the gender binary when learning about quantum concepts.

In the worlds of Wilchins, a queer theorist, "Final singular truths make perfect sense when we're dealing with measurable, physical phenomena, like the heat of a star, the size of an atom, the hardness of a rock, but almost none of it comes to highly politicized bodily characteristics like sex, gender, desire, or race" [22]. While Wilchins correctly highlights the inapplicability of positivism to characteristics such as gender, physicists also understand that on the quantum scale, a final singular truth for measurable physical phenomena may not provide the most beneficial lens to view the world.

IV. QUEERING METHODOLOGIES IN QUANTUM EDUCATION RESEARCH

Future research may seek to understand the potential epistemological advantage that queer identities offer in the realm of quantum theory. Building upon the parallels drawn between queer identities and quantum theory, scholars could delve deeper into how individuals outside the gender binary engage with and comprehend quantum concepts. By acknowledging the diverse perspectives brought forth by queer individuals, researchers can enrich the discourse within quantum education and challenge existing pedagogical norms.

However, researchers must approach this endeavor with caution, recognizing the inherent biases within academic and heteronormative frameworks [13]. As Swirtz and Barthelemy [13] note, the process of collecting data and systematically analyzing data may inadvertently reinforce existing power dynamics and perpetuate normative assumptions about gender and identity. Therefore, it is imperative for researchers to critically reflect on their methodologies, ensuring inclusivity and sensitivity to research participants with diverse experiences.

Swirtz and Barthelemy [13] caution against uncritical adoption of rigid scientific methodologies when studying human systems. By blindly applying methods from physical sciences to social contexts, there is a risk of overlooking the intricacies of human experiences and perpetuating harmful stereotypes [2, 13]. In essence, it is crucial for PER to acknowledge and include the reality that humans are involved in PER, both as the participant and researcher. Thereby introducing complexity and entanglement with the social realities that shape students' lives. This perspective aligns with Cochran et al., who argue for the necessity of understanding race in physics within the broader context of societal race dynamics [5].

In the context of queering PER, it is essential to recognize that the scope extends beyond merely addressing the needs of marginalized students [13]. As Swirtz [13] emphasizes, queering PER involves interrogating and subverting normative assumptions about gender, identity, and knowledge production within the field itself. By decentering hegemonic narratives and embracing diverse methodologies, researchers can foster inclusivity and promote a more nuanced understanding of both physics education and broader societal dynamics. Through this critical lens, researchers may uncover new insights into the epistemological advantage that queer individuals may bring to the study of quantum phenomena, thereby enriching both quantum educational research and broader scientific discourse. Furthermore, highlighting diverse perspectives expands the category of "physics student," inviting more individuals into the field who may have otherwise felt marginalized or excluded.

V. CONCLUSIONS

The examination of queer identities through the lens of Standpoint Theory and Performance Theory alongside the principles of quantum theory reveals intriguing parallels and insights. Standpoint Theory posits that individuals' perspectives are shaped by their unique experiences and social positions, highlighting the epistemic advantage of marginalized identities. Intersectionality further complicates this understanding by recognizing the intricate intersections of individuals' identities, where privilege and oppression intersect in multifaceted ways.

The ontological frameworks within physics, particularly the contrast between classical and quantum physics, mirror the complexities of human identity. Classical physics adheres to a deterministic worldview, analogous to biological determinism in understanding gender, where attributes are predetermined. In contrast, quantum physics introduces probabilistic elements, echoing Butler's performance theory by acknowledging fluidity and uncertainty in both physical and identity constructs.

Through the narratives of figures like Glamrou and insights from queer theorists such as Wilchins, it becomes evident that embracing the fluidity and complexity of identity can offer new perspectives and understanding. Just as quantum theory challenges notions of fixed truths in physics, queer theory disrupts rigid conceptions of gender and identity, highlighting the limitations of positivism in understanding highly politicized characteristics.

Therefore, in exploring the epistemological advantage of queer identities in understanding quantum theory, we recognize the potential for marginalized perspectives to offer unique insights and challenge dominant narratives. By embracing the entanglements and contradictions inherent in both quantum theory and queer identities, we expand our understanding of the world and foster a more inclusive and nuanced approach to knowledge.

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