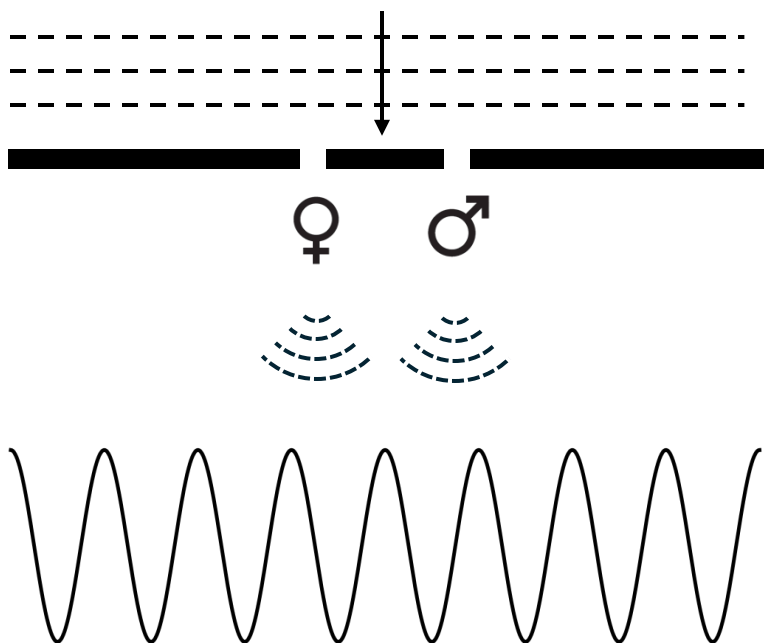


Light is Queer



Models, Ambiguity, Perception, and
the Convenience of Description in
Optical Sciences and Gender

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*For the kid on Clearview Road with
the pale-yellow comforter and the
white board on the wall next to their
bed. They scribbled down notes
about quarks and trigonometry and
folded their t-shirts with the tag
facing in.*

*This is for the kid who chewed all of
their wooden pencils to a pulp and
chipped their front tooth from biting
their nails too much.*

Look at how far we've come.

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We say light is wave or particle out of convenience.

It is neither but both.

You call me man or woman out of convenience.

I am neither but both.

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The purpose of a model is to explain and predict. Inside the framework of a model, the entity that is being studied is confined to the rules of that model. If that entity breaks a rule, a new model must be used because a contradiction now exists. Models should conform to Nature. If Nature does something that the model can't predict or explain, the model is wrong. A model, then, is used for the convenience of description. When a model is formed, there is an acknowledgement that the model might not be comprehensively correct. What's more, there are models that sometimes make simplifying assumptions about the behavior of an entity such that the model being used is *good enough*. This is pretty common when the system or entity of interest would be too complicated or cumbersome to model exactly.

Light is an electromagnetic wave which propagates in space and time according to Maxwell's four equations [1]:

$$\nabla \cdot \mathbf{D}(\mathbf{r}, t) = \rho_{free}(\mathbf{r}, t)$$

$$\nabla \times \mathbf{H}(\mathbf{r}, t) = \mathbf{J}_{free}(\mathbf{r}, t) + \partial \mathbf{D}(\mathbf{r}, t) / \partial t$$

$$\nabla \times \mathbf{E}(\mathbf{r}, t) = -\partial \mathbf{B}(\mathbf{r}, t) / \partial t$$

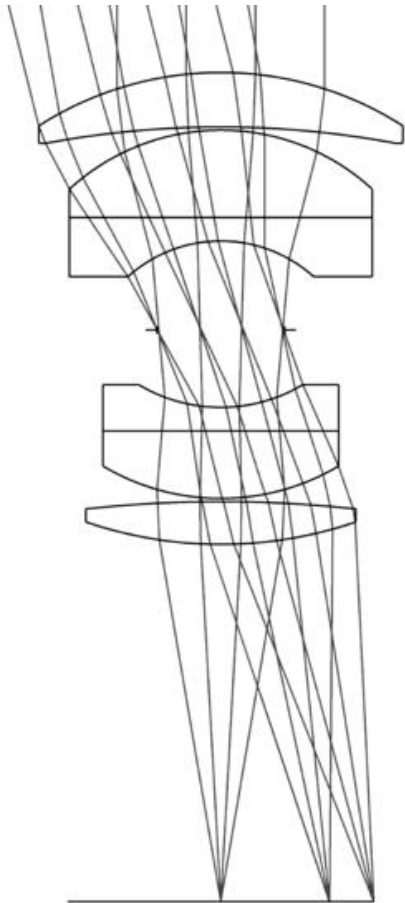
$$\nabla \cdot \mathbf{B}(\mathbf{r}, t) = 0$$

Despite this, we don't use Maxwell's equations to solve every problem in optics because we have a handful of simplifying models that adequately describe light's behavior on different scales. In the study of optics, there are a handful of such models that are used for convenience. To name a few: the ray model, the wave model, the particle model, the quantum model, the radiometric model, the model of coherence, the statistical model.

1. *Field, Force, Energy and Momentum in Classical Electrodynamics* by Masud Mansuripur

The reason we have so many models for light is because it is fundamentally queer. It exists in between regimes of description and so in order to adapt to the many ways it exists we form models for it so that we may understand it better. We use models of varying complexity depending on the complexity that the problem or situation requires. Consider as an example the design of a camera lens.

A “double gauss”
lens system
simulated in
Zemax, with rays
being traced
through it from
three different
field points.



If you want to determine “first-order characteristics” of the system, you can get away with just using the ray model and tracing many rays through the system to learn about it. Tracing a ray means following the direction of a single beam of light as it passes through the series of lenses and apertures. With this analysis you can find a bunch of useful information like what the focal length of the system is and where its entrance and exit pupils exist. Now let’s say you want to figure out how “good” the lens is, meaning, how good of an image it will form. You can use the ray model for this, but a more exact and comprehensive approach would involve using *aberration theory*. An aberration is a way of quantifying specific failures of a lens system to form an ideal image. When that’s done, you might want to put coatings on some of the lens surfaces to minimize internal reflections and improve the efficiency of the lens system. To figure out what the coatings should be made of, how many layers the coatings should have, and how thick each layer should be you would turn to the study of thin films, which requires a more detailed modelling approach. We can see in this simple example the different levels of complexity that are required to design a good lens, with each model increasing in complexity as it is required. There’s a fundamental principal in optical design: if it doesn’t work in the first order model, it won’t work in the subsequent models. So, we typically start simple and increase complexity as needed. You wouldn’t turn to Maxwell’s equations to find the focal length of a simple lens system (the rules and simplifications we make emerge from these equations but we shortcut to the simple model to save time).

Let me re-iterate an important point:

Models conform to Nature.

Not the other way around. If Nature does something that a model can't predict, a new model is needed. The model *never* confines Nature. Light has the freedom to behave in whichever way it wants. We are simply spectators with notebooks. We use models as a tool to understand light, thus, *the model itself is not the entity but a description of it.*

This brings us to gender. *The gender binary is an oversimplified model for gender.* Furthermore, instead of serving the purpose of a model, which is to explain and predict, it does a third more nefarious thing: it confines. It is not flexible to contradictions and the enforcers of the gender binary punish deviations from this model. This intensely betrays the process of science.

I'd like to make the distinction here between body and gender. When we are born, a gender model is placed on us depending on what body parts we have. But body is not gender. Gender, (in my current working opinion of it), is social platform for expression and oppression. Body *can* be integrated into gender identity, but one's body does not determine ones' gender. As a rhetorical example for how gender is more of a social identity than one which exists in the body alone, consider the phrase 'be a man!' When someone say this, they aren't saying 'change your anatomy' they are saying 'do these things which a man is supposed to do.' Or, in the linguistics of our previous discussion, 'conform to this social model of a man which we should all agree on.' Along that same line, the phrase 'boys will be boys' carries an equally implied social gravity. This could be interpreted as 'these people we call "boys" will continue to do these things which conform to our model of "boy" and any questioning beyond that simple fact doesn't make sense because certainly there are ways that "boys" should behave.' Even if those behaviors are problematic.

Now that we have placed gender in the realm of the social and not the tangible, it should be apparent how absurd it feels to collapse the entire spectrum on which a human can interact with the world into two simple models of 'man' and woman.' It's not that I have beef with these two identities exactly, but I have beef with something that I mentioned earlier: that there are *rules* and *expectations* applied to each of these models that, when someone deviates from them, they are seen as an exception and outlier. As if humans aren't part of Nature and the gender binary naturally emerged from the chaotic soup of creation at the hands of a God we call Man. Instead of rearranging the model to adjust for how humans interact with the world, the binary is *enforced*. Thus, gender roles emerge. Thus, discrimination emerges. Thus, exploitation emerges through meticulously crafted hierarchies by those in power. Gender is then seen for what it is: an oftentimes subtle but other times glaringly obvious way to restrict. The current model is wrong and a new one is due. Or maybe there doesn't even need to *be* a model. What would a genderless world look like? This is explored in Ursula K. Le Guin's famous scify novel *The Left Hand of Darkness*. But I regret to say that the world we live in isn't a scify one. Ours is a very real reality. And the human tendency to categorize and explain might be one that is too hard to overcome.

(I often struggle with this collision: my desire for being unidentifiable in gender collides with my scientific mind's desire for a model. But models, inherently, are flexible, aren't they? To what extent do I rely on models to make sense of my own reality? Am I doomed to fixate on models for things that live in ambiguity? Not necessarily, I think, because models can have a way of *abstracting* things. Some models are built precisely on this abstraction, making things as general as possible so as to include all possible sets of experiences. As a scientist and someone who has always been scientifically minded, I am driven towards this abstraction and generalization. And as an artist I am willed to a life of metaphor. So maybe it is my quest for abstraction, ambiguity, and metaphor that has guided me here. OKAY this could be a very laborious tangent but I'll end this hefty parenthetical here.)

Einstein once said:

No amount of experimentation can prove me right; a single experiment can prove me wrong.

What Einstein means here is that for a given model, it is correct until an exception is found. A model works until it doesn't explain something. Then, a new model should be developed which simultaneously accounts for the behaviors explained by the previous model *and* the new behaviors which were just discovered. As scientists, this is what we do and this is what makes science fundamentally queer: it is inclusive, it trailblazes, it's curious, it discovers, it's not beholden to anyone, it's novel.

Before I proceed, I'd also like to state:

There is community in identity.

How we choose to identify and how others choose to identify us can be a beautiful thing. However, the systematic ways in which we are identified that aim to limit our happiness, freedom, and potential is not a beautiful thing.

This collection serves not to invalidate the purpose of identity and the joy and community we find in it but to envision a world in which the way we identify to feel beautiful in our own bodies, lives, and communities is not used against us.

Furthermore, as we move toward that future of radically inclusive models for gender and gender identity (and/or the abolition of gender completely), I believe it to be incredibly important to hold space for and navigate with those who the current model has disadvantaged the most. This starts and ends with listening and takes knowing when to be savage and when to be gentle for what and who we love.

Now, revisiting light and its radical queerness. Light is one of the most beautiful of all the natural phenomena. The behavior and fundamental nature of light can be described using a variety of models which we just discussed, and scientists typically use whichever model is convenient for describing certain phenomena based on the application or problem. In this sense, light inherits many different and complicated identities. In my experience, this is a beautiful metaphor for gender identity and expression. Something, or someone, need not be one thing or the other and can very easily exist without, or, in the regime between, categories and models – it can be ambiguous. Though, despite everyone's agreement that light (a natural entity) can have multiple forms of expression and identity, there is still confusion about how a person (a complex, thinking entity with a mind that participates in chorus with other thinking entities) can exist without conforming to a gender binary. When light is *perceived* it is categorized. These models for light are *convenient for description* but light does not need to endure a category in the absence of observation. In this way, light is irrevocably queer: it shows us how naturally ambiguity exists and how beautiful it can be. Similarly for genderqueerness: existing in between categories of “man” or “woman” reveals a stunning and beautiful way of interacting with the world and reveals the meticulous ways in which the binary model of gender simplifies, restricts, and reduces the spectrum of humanity in order to stratify. What initially started as a journey in gender identity for me has quickly evolved into a sociopolitical commitment. Like sure, yes, I’m non-binary and I arrived here years ago because of inward reflection, but what does that mean to me now? What does that mean to me outwardly? Nowadays (for me) being non-binary feels like both an identity AND a platform for gender abolition. It is in this constant un-doing of my own biases and an increased awareness of gender’s subtle or not-so-subtle hand in my/our life/lives that I’m committed to investigating and undoing. I’m therefore motivated to write this collection to emphasize how effortlessly ambiguity exists in the study and nature of light and admit my frustration for how this same ambiguity is punished and discouraged in gender identity.

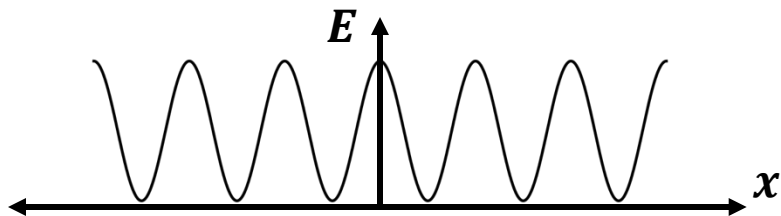
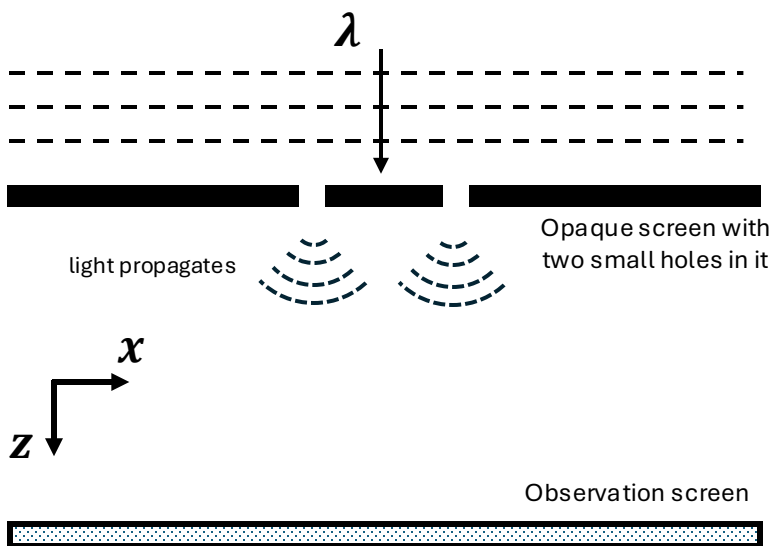
Let's revisit two models for light we previously mentioned: the wave and particle models. In the early 1800's Thomas Young ran a famous experiment which we now call the "double slit experiment" that put the wave description of light into acceptance because it was something that the existing ray model couldn't predict or explain. Around this same time Dominique-François-Jean Arago ran another experiment which rooted this theory into mass acceptance (for more information, search "Arago spot"). Thus, the wave theory became a valid model for describing light's behavior. But light is also a particle. Einstein won the Nobel Prize in 1921 for formalizing what's called the 'photoelectric effect' which uses photons (particles of light) as a way to describe how light of a particular frequency (a wave property) carries a quantized energy (see "Planck equation") and how these packets of energy can interact with other materials to release electrons. So now we have these two completely different models for light and both are used and widely accepted. THAT IS QUEER. What's more queer than saying "hmm, light does this thing here but it also does this other thing here so why don't we just call it both and neither. Good? Good." !!! AHHH! FJEIFJEIWJFEIJF.

Now I'd like to investigate a metaphor between a really cool optics experiment and genderqueerness. I'd like to preface this by saying that I'm only going to share a pretty high-level overview of this experiment with a few simplifying assumptions, without wading through quantum mechanics and other cumbersome (but interesting) things for the sake of making a point. But believe me when I say that as you dig deeper and deeper into this it just keeps getting more queer (questions like: how does the act of "observing" change behavior, superposition of states in Hilbert space, wave equation shenanigans, probability density functions, etc... all very queer). My discussion will focus on the wave behavior of light and how continuity emerges naturally from a binary. We'll talk about diffraction and interference of light, and extend this experiment as a metaphor for genderqueerness.

The situation we wish to concern ourselves with is how the “shadow” of a screen with two small holes in it looks like on an observation screen at some significant distance away from that screen. Think about this: you have a piece of paper and you poke two holes in it. Then, you shine laser light at those two holes. Light will only pass through the two holes and be blocked everywhere else. Then, that light travels some distance and lands on the observation screen. What would we see? From what we know about shadows and light how we ordinarily interact with them, we might expect to see two bright but slightly blurred points on the observation screen. BUT. Laser light isn’t like light from the sun or from a light bulb. Laser light has a special property of being *coherent*. Light that is sufficiently coherent has the ability to *interfere* with itself. Think about water waves: while waves are travelling on the surface of water, they interact with each other. Regions where two waves are high make an even bigger wave. Regions where one wave is high and one wave is low results in there being no wave amplitude at that point. This is “wave interference.” Turns out, light also does this! However, it’s only observable if you are using light that is sufficiently coherent. You can think about coherence as a metric for “how well can a light wave interfere with itself.” It will form these regions of high and low, bright and dark, regions, and we typically call these “ripple” patterns *fringes*.

So, what would we see? Well, if we assume that the holes are small enough and close enough together and the observation screen is sufficiently far away from the screen with the holes, you would observe a *continuously varying* shadow! The brightness on the screen actually varies sinusoidally!

Collimated laser light of wavelength λ travelling in z . Dashed lines indicate planes of constant phase.



Irradiance E on observation screen as a function of x

To understand the reason for this, once again consider what we said about waves. We can think about the two points in the screen that let light through as the source of two waves which propagate with a spherical profile away from the screen. The darkest regions on the screen correspond to points where a peak of one wave interfered with a trough of another wave. The brightest regions correspond to points where two peaks interfered. In between those two regions there will be some combination of these two conditions, resulting in a “continuously varying shadow” which oscillates between bright and dark.

**CONTINUITY NATURALLY EMERGES
FROM A BINARY RESTRICTION!**

This leads me to the reason I think this is super-duper queer. The screen with the two holes can be thought of as a metaphor for the way that the binary tries to limit us. It is rigid, opaque.

But there must be more than this opaque screen has to offer.

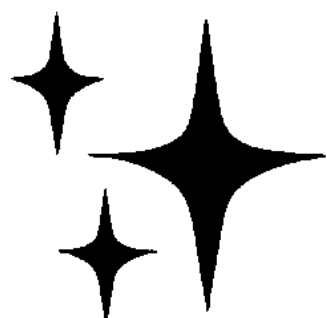
We interact with this structure. *And from that structure, it should only be natural that a continuum of lived experiences emerges.* Call this trans, call this genderqueer, call this non-binary, call this human (even cis-gender contains this continuum!). And so, the call for gender abolition is not one that would lead to homogeneity, but quite the contrary: it would allow for continuity where there wasn't one before [1]. Audre Lorde also expresses: *The need for unity is often misnamed as a need for homogeneity* [2]. There is a call for embracing, not weaponizing, our differences and using those differences as power to catalyze positive change. Lorde also comments [2]:

Certainly there are very real differences between us of race, age, and sex. But it is not those differences between us that are separating us. It is rather our refusal to recognize those differences, and to examine the distortions which result from our misnaming them and their effects upon human behavior and expectation.

Bey further writes: *Gender abolition is the abolition of the enforcement of categorization* [3]. It is the active refusal and undoing of the categories, expectations, and limitations created by the binary that need to be dismantled.

1. *Cistem Failure: Essays on Blackness and Cisgender*, pg. 136, Bey
2. *Age, Race, Class, and Sex; Women Redefining Difference*, Lorde
3. *Cistem Failure: Essays on Blackness and Cisgender*, pg. 143, Bey

Light is queer because it subverts expectations unless you take the time to get to know it. It's queer because it's known by many names and by many models and many different forms of description. Light is queer because it shows us that ambiguity can exist across models. Light has an "un-identity" in the sense that it is described in many different ways in many different circumstances. This nega-identity even in the presence of models (particle, wave, ray, etc...) is incredibly inspiring to me. Because even though I want to exist as a genderless entity, models ~will~ emerge. Still, many will create a model for me. Some of these models will have nicer names than others. But a model is just that - a desperate way to make sense of something, sometimes out of curiosity and love, sometimes out of fear. If and when we make these new models for gender, they must be crafted out of love. Or maybe all the model needs to be is "we are beautifully, ambiguously: human."



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About the author

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$$|gnero\rangle = \alpha|\sigma\rangle + \beta|\varphi\rangle$$

Where $\alpha = \beta = 0$

Is a 5th year PhD student in Optical Sciences at the University of Arizona with interests in computational imaging, optical engineering for augmented reality displays, and free-space optical communication. Their graduate work aims to develop next-generation technologies and techniques in optical channels that receive (imaging), send (display) and communicate (optical coms) information. In addition to their work in the natural sciences, they are also involved with gender studies. Recently, they have been interested in how gender is simultaneously used as a platform for expression and as a tool for oppression. In their spare time they enjoy bicycling, writing, going to live music events, and being in community. <3

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