**Transcript**

**Speaker** 1: You're tuned in to 90.7 FM, k a l x, Berkeley. My name is Tesla Munson. And this is the graduates, the interview talk show where I speak with UC Berkeley graduate students about their work here on campus and around the world. Today I am joined by Hillary Jackson, the physics department. And a, you're a fourth year, is that right? And Hillary? Yeah, that's right. Uh, so just before we even start anything, what kind of physics do you study?

**Speaker** 2: Yeah, I do experimental condensed matter. Yeah. So are there like branches of physics [00:00:30] here at Berkeley and does that fit into one of them? Absolutely. That, that is one of the branches of physics. Yeah. So what are some of the other ones just so we can orient ourselves? Sure. So, um, the, I'd say the two main branches are experiment and theory. And um, so for each kind of field there tends to be an experimental side and a, uh, theoretical side, uh, physics didn't use to always be like that. Um, but my guess is for at least around a hundred years, it's kind of been separate. [00:01:00] Where, so for example, if you work in particle physics, you either are a particle theorist or a particle experimentalists and, uh, they talk to each other. Okay. And then, so we'll break down the other part of that. What is condensed matter? Sure. Condensed matter traditionally is a theory, or maybe not theory, but the study of solids, there is something called soft condensed matter, which some of what I do kind of falls into that, which kind of includes liquids [00:01:30] or things in between solid and liquid.

**Speaker** 2: Okay. So you're studying experiments on solid objects. I do experiments on solid objects. You do experiments on solid objects. Okay. Are they large or smaller? They're very small. Um, the solid objects that I make are, um, I work in thin films in particular. So at the atomic scale, they're still, uh, three-dimensional, but kind of on more our scale, [00:02:00] they're more two dimensional just because they're so small. Yeah. Yeah. So there may be, I don't know, 300 nanometers thick, um, to give context. Um, so, so 3000 angstroms thick and an atom is about an Angstrom. So like 3000 Adams. Yeah. It's that sick. Yeah, like a piece of paper that is thinner than amazing. Okay, cool. That's good to know. Yeah. I believe I haven't measured a piece of paper, but, but it should be, I mean that's a, that's a good, that's a good first, [00:02:30] first step at, at I think kind of visualizing what's going on. And then the, the area, they're probably at most maybe a centimeter squared. Okay. Okay. So small. Yeah. Small. Yeah. Yeah. But lots of Adam's still so, so enough. Okay.

**Speaker** 1: Awesome. Okay. So before Adam's there, there was a beginning. How did you, how did you end up at UC Berkeley? I know you had a pretty interesting path as far as far as

**Speaker** 2: graduate students go. Yeah. Yeah, I'm pretty nontraditional, so I always loved, um, [00:03:00] I did art as a kid and um, in middle school I was part of a magnet program at the local public middle school and I started out in photography, uh, for two years. Then I'm moved into fine art and I went to fabulous fine arts high school. This is all in Miami where I'm from. Um, so I was pretty much brought up on being an artist and developing as a person in the context of developing as an artist. Um, I did art at school for [00:03:30] at least three hours a day and then went home and, and did more all of the time. Um, so after that kind of the, the Goto track was to go and get a BFA, which is a bachelor's of fine arts. Um, so I did that at the school of the Museum of Fine Arts in Boston and, uh, quit three years through for various reasons and went back to Miami to live by.

**Speaker** 2: Uh, I moved to South beach and I waitressed and that a lot of partying out of my system, [00:04:00] uh, which I think was really good for me actually. And then I went and started doing science at the University of Miami. It's kind of the local university and somebody told me that I could possibly be a pharmacist, that that was a really steady job and uh, it was pretty easy to do. So that's what got me started taking science classes. Actually, I didn't really have any interest in it before that. I was always kind of good at it, but I didn't really care to be frank. So I quickly realized [00:04:30] that I could probably or probably wanted something more creative than pharmacy. And so I, um, was on a pre-veterinary track. So I was a bio major and a chem minor and I worked at a vet hospital, which I have some very dear memories that go along with that.

**Speaker** 2: And I had to take a physics class as a requirement. And even though I thought I was really terrible at Calculus, my calculus teacher told me that I was actually really great at calculus [00:05:00] and then I should take calculus based physics because calculus was invented for physics. And if I took physics without calculus, it wouldn't make sense to me. And she knew that that would drive me up a wall. So I took calc based physics and fell enough and added on a physics major and a math minor. And here I am. I applied to graduate schools only in California, only in California. I do. What's the reasoning behind that? Um, I did not want to go back to the northeast. Being from Miami, [00:05:30] the snow, it just, you know, it hurts your face to be outside nine months out of the year. I, I'm not okay with that.

**Speaker** 2: There are enough good physics schools out here too that I figured I really wasn't sacrificing anything. Yeah. You must be a little bit like me to where you won't kind of want to be near water. Yes. Very important to me. Yeah. Yeah. Awesome. Well, yeah, so you went all the way from fine arts to physics. It's a pretty long journey, but obviously a little bit related because you made it so, um, and said you wanted something creative and uh, [00:06:00] you told me a little bit about your work earlier. You, you said it was sort of fringe. So, uh, before, I guess before we get into that, did you do any, like what were some of your undergraduate science experiences? Did you work in a lab or did, what did you do there? Sure. When I was focused more on biology, um, I was actually really invested in botany and so I did a few experiments.

**Speaker** 2: I'm kind of at the university arboretum. We did some, some mass spectroscopy on [00:06:30] some of the plants to kind of see what some of their light cycles were like and how, how they differed, um, amongst one particular genus. So that, so that was really fun. And I still, I still really adore plants so I did some of that work. But in physics I did some theory though. Theory these days tends to be mostly particle theory. Um, I did theoretical statistical optics, so that was work on the theory. The theory of disordered light is kind of a way of describing it. Um, so the light [00:07:00] that comes from the sun is, is something that we would call maybe perfectly disordered if, if there is such a thing. And that's compared to maybe the light from a laser, which is one particular type of light and it's very organized.

**Speaker** 2: Um, so I did theory on not just light from the sun but, but once the light from the sun passes through the atmosphere, it does gain some, some more order so to speak. So I kind of did theory on the light that [00:07:30] we see everyday light that passes through clouds, how the disorder changes, um, when light passes through other disordered materials like clouds or even skin. So what makes sunlight, as you said, perfectly disordered, what, what properties like in the, in the most general terms. Sure. So it's, it's not polarized, so it doesn't have, um, it doesn't have a particular kind of direction by direction. I don't mean direction that it's [00:08:00] traveling, but the light itself doesn't have any kind of orientation, uh, without doing drawings. This is kind of difficult. Um, and it's also in coherence, so that means that the wavelengths aren't lined up.

**Speaker** 2: But then, but you said it's still perfect. What, uh, perfectly disordered. We think of it like that, that was language that I used as an Undergrad in any case. Um, so there's, there's degrees of, of disorder. And so that was, that was kind of one extreme that I was using to indicate that. And on the other extreme is really is a laser. So, [00:08:30] yeah, by perfectly disordered, I think, I just mean extremely disordered. Very cool. OK. And then, uh, and is that related at all to your work now? I think it is. Um, they're mostly in the way that I conceptualize things in, in the way that I visualize things. I think that what I did as an Undergrad really helped my brain kind of rap, wraparound, some, some ideas of disorder that I use. The theories don't really play into each other every now and then there's [00:09:00] like a, a hint of something that I do that I do now that reminds me of a theory that I touched on as an Undergrad, but mostly the language is very different. But the way I conceptualize them are they're similar. Yeah.

**Speaker** 1: If you're just tuning in, you're listening to 90.7 FM LX Berkeley. My name is Tesla Munson and this is the graduates today I'm speaking with physicist Hilary Jax, who was telling us about her route from Miami to Berkeley, uh, from art to physics [00:09:30] and from optics to experimental condensed matter, which, uh, solids. Okay. So let's go back to that a little more. You said it's small, this a thin plate, thin films, thin films. So, how do you do experiments on this type of stuff if it's so small for one?

**Speaker** 2: Sure. Um, so our, our lab is really cool in that we both grow these thin films, um, grow as a verb. I can describe more later if you'd like. Um, but, but we [00:10:00] make these thin films and then we characterize them. And so there's, there's kind of a two pronged approach to any question that we have is like, can we make it, how do we make it and then how do we describe what we've made? And we do both in the lab. So, okay. Does that mean you don't know what you're going to get when you make it? Yes. That that is true. So most, most condensed matter. Um, and this is why what I do is kind of fringe. Most condensed matter is concerned with crystals or things that are [00:10:30] similar to crystals. So crystals that have a little bit of of disorder, so things called defects.

**Speaker** 2: Um, and a crystal is a material where all of the atoms are arranged in a very particular pattern. And the idea there is that if you know where one Adam is in a perfect crystal and you know the distance and the orientation to the other atoms, then you know where all of the atoms are in the system and condensed matter. Physicists [00:11:00] are mostly concerned with crystals in my opinion because you can do math on them fairly easily cause you know where all of these atoms are and so they're, they're tractable in that sense. My work in particular is concerned with things that aren't this and so it's true that any condensed matter experimentalists when they, when they grow a material, whether they're trying to grow something crystal and or a morphous amorphous is another word for disordered. They don't know what they're going to get, [00:11:30] but most of the time people are hoping for a crystal and there are certain growth conditions that they can use where they're, they're pretty sure they're getting at crystal and you can make measurements afterward to make sure that you are getting them.

**Speaker** 2: But my not knowing what I'm going to get, I think is, is more than that because I'm looking in particular at different types of disorder and that's relatively unexplored. Um, it's the, the conditions that you need for different types of disorder, whatever that means, [00:12:00] that's not even really well defined currently. The conditions that you need are materials dependent. So it depends on what you're growing. And then also there's a question of repeatability. So if I am growing, I'm a disordered atomic system and I grow for four of them the same way, there's no guarantee that they're even the same disordered in the same way. And so I, I really don't know what I'm getting. So have you made progress [00:12:30] on that front or is it still a mystery every time? Yeah, yeah, no, we've made some progress, um, in, in what we call kind of mapping out the phase space is the language around that.

**Speaker** 2: And the face space is just the, the space of all of the, the parameters that you can change. So things like the substrate temperature of, of what you're growing your material on as you grow it. Um, the rate of deposition. So how quickly the Adam's lay down on top of each other, the kinetic energy that those [00:13:00] atoms approach the substrate with the these things. Yes. Yes. We've, we've made some progress in mapping out the face space. We have some ideas about what gets us, what. So for people like me and probably like many, many people who just don't know very much about physics, what is, what should the public take away from this? What is the applicability to things we can understand? Sure. So I'm working mostly with silicon for me. So I think there are two answers to that. One [00:13:30] is, one is an answer that I'm really mostly interested in, which is kind of more, this is interesting because our brains usually are very bad at processing disorder, right?

**Speaker** 2: Our brains look for order and things and if I showed you three pictures of these disordered Adams that I grow that physically are different types of disorder and you looked at them, you probably wouldn't be able to tell the difference. And so there's something [00:14:00] mysterious there. There's something that exists that our brains can't get at for easily. And I think my work is trying to elucidate some of that. And so, so I love that. I think another application is, um, is kind of particular to silicon. So silicon is a semiconductor and silicon is in pretty much all of the electronics that we, that we use, cell phones, computers, whatnot. And a lot of these circuits, the way they're built is [00:14:30] they're, they're built by growing silicon thin films. And that silicon is almost always a morphous or disordered. So largely people in the past have just said, oh, we're growing disordered silicon.

**Speaker** 2: It's all the same. It's all disordered. And there are these variations in properties that we see. So, so there are electronic properties that change in these different types of disorders. But if you're clumping all the disorder together as the same thing, then you can't really [00:15:00] handle those properties. You can't control them. Um, but if we can kind of do a better job at parsing the types of disorder then, then yeah, I think we can harness these properties and put them to use for, for electronics. And photovoltaics I'd say are probably the main applications. So, so solar cells. Cool. Oh, that gets into a whole nother dimension. How solar cells. Yeah. Yeah. I'm, I'm really more kind of at the, at the, the fundamental level right up [00:15:30] in terms of like looking at the, the atoms and, and I don't look too much at, uh, at kind of downstream in terms of how industry produces them, how cheap they are to produce, how, um, I do know a little bit about how long they last.

**Speaker** 2: Um, no, that's, that's really cool. Uh, so I know you're also involved with outreach here on campus and I was hoping we could hear a little bit about that. Yes, of course. Yeah. Um, I'm heavily involved with a group called the compass project. The compass project is really cool [00:16:00] for a lot of reasons, but to me what's really important about it is that it's all student run. It was student founded in 2006, um, by a group of graduate students. In the physics department though, um, we do include, um, other physical sciences and, um, so we're concerned with making the community more accepting of diversity. Physics is notoriously bad for being, uh, homogenous [00:16:30] homogenous both in, in terms of demographic. So you have like middle to upper class white men. Um, it's kind of the standard physicist and I hear all the time, oh, you don't look like a physicist.

**Speaker** 2: And that's because I feel like I don't look like an upper middle class white man. Um, shocker. Yeah. Believe it or not, I've actually said this on the show multiple times where we've had like a reveal. You are not talking to an old white man. So I'm glad I can add this to the list. Yeah, yeah. I don't look like that. I [00:17:00] probably do look more like an artist. I'd like to think that. Anyway. Uh, so, so yeah. So compass uses kind of cutting edge alternative pedagogical approaches, um, to learning science that focus on forming community that is inclusive. I'm not just accepting of diversity, but really valuing diversity, saying, hey, you have this background, you have this perspective that is bringing something new to the table. And I value that. So we, [00:17:30] what do we do? We, we do a lot of things and we're pretty busy, but we run classes.

**Speaker** 2: So we have, uh, two classes for freshmen and sophomores. We run a transfer course. So that's particularly geared towards students who are mostly coming from community colleges in their junior year. So, so they face kind of a different set of challenges and they come in here and they, they often have a different background than somebody who just kind of came straight from high school [00:18:00] and it was, you know, spends their four years here. We also do, I'd say our flagship program is really a, it's a summer program. It's two weeks before freshmen start their traditional courses here. And we focus on a project. So for example, I think last, last summer, the, the topic was what can light tell us about matter? And so we select 20 students, about 20 students. Um, [00:18:30] it's all expenses paid. Uh, we raised that money also. So encompasses really all kind of, yeah, we, we get a lot of help for sure.

**Speaker** 2: I don't, I don't mean to imply we do it all on our own, but, but it is all graduate, graduate and undergraduate student run and um, so these students engage in, in kind of a community learning classroom for every day except for the weekends, for two weeks. And then in the evenings they do other community building activities. And the idea there is that [00:19:00] they're forming a community kind of before they enter into the, uh, the usual like Undergrad rat race that my understanding is here. Often the competition is fairly unhealthy and it tends to affect, uh, people from diverse backgrounds more man. Oh. So yeah, it does sound like you guys do a lot of things. Uh, how many graduate and undergraduate students would you say are involved in like keeping it going and running compass? Eh, there's kind [00:19:30] of various levels I'd say at the, at the center core, um, so we're particularly non-hierarchical.

**Speaker** 2: We use consensus based decision making and we call ourselves a do ocracy. So if you show up to a meeting, your opinion counts just as much as anybody who's, who's been there for, for three years. So our numbers fluctuate. I guess what I'm saying is, is that there's no fixed number, there's probably about four or five of four or five graduate students right now kind [00:20:00] of at the core. And, and that, that works out really well because our schedules vary. Like I might have a week or two where I really need to be in lab and getting stuff done and I can say, you know, hey John or Jesse, you know, can, can you, can you handle this now? And we kind of keep, we keep each other in the loop and that's, that's been a really good model for getting things done and not pressuring a particular person too much. Um, we would like more people. Um, [00:20:30] I'd say we're probably a little bit low on numbers now relative to the programs that we run, but yeah, four or five in the core and kind of moving out from there. I'd say there's probably 10 or 15 more grads and undergrads that are, that are kind of involved a little bit more peripherally. And how long has the program been active? Uh, it was founded

**Speaker 1:** in 2006. 2000. Nice. Wow. So that's how I, that sounds like a really great program. And uh, I mean, yeah, I mean, what more can I say? So you've got a lot of diversity [00:21:00] in the, would you say there's a lot of diversity in the physics undergraduate population here?

**Speaker 2:** Yes. That's great. Yeah, I would say that definitely. Yeah, both, both again in demographic and in background. I really like too, I think it's probably my background as an artist where I, I really emphasize that kind of broader view of diversity. I don't think it's just about being African American or being gay or, or whatever, you know, whatever background it is. I really think diversity is about, to me it's about perspective. [00:21:30] Um, and demographics can contribute to that perspective. Um, but other things can too.

**Speaker 1:** So what, what would you be your advice for students? A high school or undergraduates or just students in general who, you know, maybe they don't quite know what they want to do or maybe they know they want to go to graduate school, but it seems too far away.

**Speaker 2:** Yeah. Gosh, that's really hard. Um, I mean I think things worked out for me, but I certainly didn't know what I was doing. I will say that [00:22:00] I always did things that interested me and that ended up I think working out. I mean, there are, there are things that, there are skills that I learned as an artist that I use every day as a physicist that I think are really invaluable. And I think, Eh, Eh, and the same goes for, for a lot of the skills that I learned when I was more focused on biology. And I really think that if you just keep doing things that interest you, it'll all come together in some way, at least internally. [00:22:30] Right? It may not be that you have a career that combines all of them, but you, you use things that you learned from the things that interests you. I would also probably say that I think the way society is set up, we place really ridiculous expectations on young people. When you're starting out as a freshman and people ask what you can want to do, it's like, what are you, 17 or 18 I think that's unreasonable.

**Speaker 1:** And what would be your advice for undergraduates coming from diverse backgrounds other than getting involved with compass of course. But [00:23:00] do you have other advice you can give?

**Speaker 2:** Yeah, I would say to find a community that supports what you do outside of your major or your school work. It's, it's really hard to, to have a life outside of schoolwork, especially as an undergraduate. As a graduate student, your schedule is a little bit more flexible and you can kind of make time to do other things. But as an undergraduate, I think making sure you make some time to do things that's not schoolwork, that values your own diversity. [00:23:30] Um, and having a community that does that with you. And by community I really mean, even if it's just one person, it's like, Hey, I know, I know you really like art. Let's go to a show. I think that's really important.

**Speaker** 1: And for students who might be in applying for this pre a freshman

**Speaker** 2: program, where do they look for that application? Oh sure. I'm, well they can find it on our website. Believe we are Berkeley compass project.org or at least you can Google the Berkeley campus project and [00:24:00] find us. Um, yeah. Yeah, find the application there. We, we, we go through them every year around. We start accepting applications a little bit after students have heard, I've heard back that they are, that they're accepted to cal. Um, so kind of starting then you can apply and then we look at the applications probably for maybe a month or two after that.

**Speaker** 1: Yeah. Okay. Well I think we're just about out of time here on the graduates. Do you [00:24:30] have any last words for us?

**Speaker** 2: I would probably add that one way. I'd like to see the science culture change probably nationally I can say at least is, is I think that the thinking right now is very homogenous and homogeneity is dangerous. I think we know that logically, but I think there are certain, certain things about the science culture that really promote one way of, of being like kind [00:25:00] of promote one particular lifestyle over other ones. And uh, one way of thinking about science and, and I think that's dangerous and, and not just because you studied disorder, right? No, not just because I studied just of, I mean you can see it in ecological systems, right. So, no,

**Speaker** 1: that's great. So I want to thank you so much, Hillary, for coming on the show today. Thank you. Yeah. So it, you've been listening to the graduates here on [00:25:30] Calex. My name is Tusla Munson and today I've been speaking with Hillary Jackson, the Department of physics. She's been telling us about her path to graduate school and her work in experimental condensed matter and also her work with the Berkeley compass project, which promotes diversity and community in physics, undergraduates here at cal. So lots of great work coming from you, Hilary. And thanks again for being here. And uh, yeah, stay tuned. The graduates. We'll be back in two weeks with another episode, [00:26:00] but until then, you're listening to 90.7 FM k a l x Berkeley.