

Emma Byrne 0:02

Hello, and welcome to this episode NonFicPod with me, Byrne.

Georgie Codd 0:06

And me, Codd.

Emma Byrne 0:08

Our guest this week is Dr. Chanda Prescod-Weinstein. She's a cosmologist, and a particle physicist, and an absolutely brilliant speaker. Reading her book, 'The Disordered Cosmos' took me right back to when I saved up, I think it was my Kellogg's tokens, to send away for a popular science book, and got 'A Brief History of Time' by Stephen Hawking. Georgie, were you part of the 'Brief History of Time' train when it came out? Or were you a little young for that?

Georgie Codd 0:37

I guess I must have been too young. I remember sending off cereal tokens for the that little professor man from Weetos (note: other cereals are available) but nobody ever sent me a bloody physics book, damn it! How old were you reading 'A Brief History of Time'? I must find this out.

Emma Byrne 0:54

I must have been in my almost teens, probably about twelve, thirteen. And a lot of it I didn't entirely get, but it was written in such an accessible way. But yeah, Dr. Prescod-Weinstein's book just took me back to that desire to understand something that is so out of the realms of everyday experience. So she talks in the book about things that happened in the first few billionths of a second of the universe forming and things that are 7000 light years away. And these are scales that I just have nothing you know, you can't do that in areas the size of Wales or length of London bus. Really, you have to go to the pure mathematics to grok this stuff. So how excitement is really infectious? It's a great interview. Excellent. What did you think listening to Chanda?

Georgie Codd 1:52

I loved listening to you guys chat. I felt a bit out of my depth on some of the physics stuff, but in a way that was pleasurable. I also love her the sound of her voice. She's her voice is amazing. It's so good. Like,

Chanda Prescod-Weinstein 2:08

oh,

Georgie Codd 2:09

tell me more.

Emma Byrne 2:10

Yeah, yes. Tell me more about neutron stars and why you adore them. Stay tuned for this interview because it has not just got physics. It's got sociology. It's got history. And it's got all wonder and an awful lot of excitement from a fantastic speaker.

Dr. Chanda Prescod-Weinstein is a theoretical cosmologist and a campaigner for inclusion in physics. She's an assistant professor at the University of New Hampshire, and is working on the NASA STROBE-X mission. Dr. Prescod-Weinstein recently received the 2021 Edward A. Bouchet award from the American Physical Society, in recognition for contributions to theoretical cosmology and particle physics, as well as for her campaigning work. 'The Disordered Cosmos: a Journey into Dark Matter, Spacetime, and Dreams Deferred' is available now. Thank you so much for joining us, Dr. Prescod-Weinstein.

Chanda Prescod-Weinstein 3:12
Thank you for having me.

Emma Byrne 3:14
So if I can begin at the very beginning, there is stunning diagram near the start of 'The Disordered Cosmos' in which you lay out the timescales in which the universe began. The Inflationary Stage - that initial faster-than-the-speed-of-light period - lasted tiny fractions of a second, but from there, we climb up this log scale, and matter doesn't arrive for, I think I'm right in saying, 400,000 years? How does it feel to have to encompass timescales so many orders of magnitude apart?

Chanda Prescod-Weinstein 3:41
Yeah, I would definitely say being a cosmologist is very nonlinear. And something I like to remind my students - I actually taught a cosmology seminar for PhD students last semester - is that this is something that you get intuition for it by working with it. So nobody's born with intuition for it; it's something that you work for. And, yeah, these questions about timeline: so there's really there's a lot that happens in the very first, in the first three minutes. And in fact, there's a very famous Steve Weinberg book called 'The First Three Minutes'. And so Steve Weinberg is a particle theorist who played a really important role in establishing a lot of our understanding of the Standard Model of particle physics. The inflationary era happens at about ten to the minus forty-one-ish seconds, that's a little bit... So you know, if you think about, like, a decimal point with like, a lot of zeros afterwards, right? Um, by the end of the first three minutes, we basically have the seeds of matter, so we have a lot of particles floating around. And what we have is a kind of like, stew of quarks that is starting to condense into, into other things. And so you have this kind of like plasma of particles and photons and quarks and all of these things, until about somewhere between three hundred thousand and four hundred thousand years. And then at that point, the plasma actually yields, and the universe becomes transparent to photons. So photons can start flying freely through spacetime at that point. And that point is something that maybe people have heard of (if they, if they read my column in New Scientist or something like that, if they're some kind of nerds) it's known as the cosmic microwave background radiation. So we actually can still see those photons, they correspond, their wavelength corresponds to a temperature of about 2.73 degrees Kelvin, so they're very cold. So what's

interesting about that, is that I just told you a story that ranges from ten to the minus forty-one seconds, to three minutes, to four hundred thousand years. And then I said: "We can still see the photons, and now we're at, like the 14 billion year point," right? I'm, you know, nobody's born knowing that story! [laughs]

Emma Byrne 5:54

You mentioned the word "intuition"; it is outside of intuition, isn't it? And requires so much in terms of observation and painstaking theory, one of the things that really blew my mind about that, the graph that you present, is the fact that we're still not quite sure how things went from being really chilly after this massive expansion to warming back up again. How do you feel knowing that there are these tantalising mysteries still?

Chanda Prescod-Weinstein 6:22

It's why I do my job, right? And if we, if we figure it all out, then there's nothing left for me to do. So actually, when I give... I give a lot of presentations about my research, because it's actually, that's part of my job is to go around and give talks to other physicists about what I'm up to. And when I know there are going to be a lot of students in the audience, I spend a decent amount of time like introducing, you know, the problems that I work on. And one of the things I really like to emphasise these days, is that science is about what we don't know, it's not about what we know. And so actually being stuck on a problem - the *field* being stuck on a problem, not being able to sort something out - is really good news for me, because it means I get paid to think about the problem. So I don't see that as a problem at all. The the thing that you're specifically referring to is an era right after the inflationary period called reheating and eventually reheating. And I'll tell you that reheating stresses me out for, [laughs] for a different reason, which is: there's always this question of being able to test our theories, and therefore being able to gather data. And so I mentioned the cosmic microwave background radiation. It is hard, but not impossible, to gather information about the time period before the universe became transparent to those photons. And so one of the things that I worry about a lot is: "Will we ever be able to see evidence of what happened during that reheating time period? During the first minute or so?" Yeah, so I worry about that. I think, as on the theoretical side doing math, we're fine. [laughs] The question is always: "How will we test our ideas? And how will we find evidence that points us in the direction of good ideas?"

Emma Byrne 8:08

Hmm, where would it leave its footprints?

Chanda Prescod-Weinstein 8:10

Yeah.

Emma Byrne 8:10

Something that's that far back? Yeah. And speaking of scales, you exhort your readers to look at the Pillars of Creation in the Eagle Nebula, which is one of the most stunning pictures that I've ever seen. This star nursery is, you tell us in the book, seven thousand light years away, and six

light years across. Again, how do you relate to physical structures so large? And is this where having a real love of mathematics comes in?

Chanda Prescod-Weinstein 8:36

I definitely think that math helps, right? I really, I've started to realise, really over the last couple of months, that I think understanding orders of magnitude (so, powers of 10) is actually a social justice issue. Because we have people in our governments who are spending these large sums of money, we have rich people who may or may not be paying their taxes, or maybe hiding large sums of money in places where they're not required to pay taxes. On some level, the entire system is relying on everyday voters, not necessarily having a good intuition for what the difference is, for example, between a billion pounds and a million pounds is. And that it's not just like: "Oh, there are three extra zeros there." But that this is actually like a million is a small percentage of a billion! [laughs] A million pounds, a million dollars, whatever, is like a lot of money, right? But it's actually not a lot compared to what the budgets of our governments are. So I just want to draw that connection, that having an intuition for these numbers is not simply about understanding the cosmos or having an intuition for the cosmos, but it's actually about our ability to democratically participate in the society that governs our lives. I do think that something like the Pillars of Creation can motivate us to get good with those numbers. And that if that's your motivation, that's maybe more fun motivation than like worrying about, like, what is the Prime Minister doing, and how much is the Home Office spending on deportations of Windrush children. One way that I always situate myself is when I look at an image like the Pillars of Creation, which is like, you know, a small piece of a larger structure, I remind myself that every little dot that I can see resolved in the picture, every little bright spot, is a star. And our sun is pretty typical. So, first approximation: it's like the size of our Sun. And I have some intuition for how much bigger the sun is than the earth. And so then I think there might be like a little tiny, tiny earth that's orbiting that star that I can't see. And that helps me understand what is the scale of the picture that I'm looking at. So again, not something that I'm born with, but I know enough information that I can look at it and situate my own sense of scale in context.

Emma Byrne 10:52

I think that that familiarity with the idea of orders of magnitude being a social justice issue doesn't come up enough in mathematics education. I remember when I was much younger, in the early days of the internet, there was a website that I think was called powers of ten?

Chanda Prescod-Weinstein 11:07

The video?

Emma Byrne 11:08

Which showed... Yes! started with like, just a person on a, on a mat and went up in orders of 10, and down in orders of 10. And things like that, that bring scale home, I find just incredibly powerful. Um, you have a chapter called "I Heart Quarks", and you clearly do! Neutron stars you *stan*, what is it you get excited about with neutron stars?

Chanda Prescod-Weinstein 11:32

I actually think they're connected, and I really think that probably I didn't do a good enough job of drawing that connection in the book. But I'll just say that I'm saving that for the next one, and it was all planned out. And, you know, neutron stars, I always have this like, sort of running argument with my friend, Joey Neilsen, who's a black hole expert, about whether neutron stars are cooler or black holes are cooler, and I'm definitely I'm on Team Neutron Star. [laughs] Because like black holes are just like strange spacetime things, but neutron stars are like these really weird, extremely compact... Like, if you think about just taking, you know the mass of the sun and squeezing it into an area that's smaller than like, um, Los Angeles or London. I would say it's like extremely dense, it's like the densest stuff in the universe. And there are all kinds of weird Lake, quarks, superfluids and plasma, and it's just like, it's a it's a strange object. And then they also have these really strong magnetic fields. You know, one of the very first way that neutron stars were truly observed were because of these, like, powerfully rotating, like, they're like lighthouses. [laughs] So um, yeah, I don't know. I mean, you can tell from my enthusiasm. I really like them. I think it's okay for other people like Joey to be wrong about that, because, um, *somebody* has to think about black holes.

Emma Byrne 13:04

I love how in the book, that idea of something that is both freaky and observable is such a great thing to glom on to, for physics. Uses of physics are manifold; from medicine, to cosmology, to sending us to space. But I'm surprised when I ran across a mention of astronomy being used in survey work. And the name Benjamin Banneker who - it may be that I'm British, but I suspect that it's not - I hadn't come across his name before. Can you tell our listeners more? I mean, you talk about him in the book. But can you tell us a little bit more about his work and why he's important?

Chanda Prescod-Weinstein 13:44

Yeah. So, Benjamin Banneker was an African-American astronomer, he was born free. He was a contemporary of Thomas Jefferson in the 18th century. And Banneker's notable in a couple of different ways. I think one is that, even though his name is a name that we know, and he's unusual for that as, as a Black person who was doing science in a way that is acknowledged by larger society, as "This is official science," and in particular, "This is official astronomy," there is a lot that we don't know about him, because a lot of his papers were lost, they were burned. And so he remains this kind of like enigmatic figure where there are also rumours about what role exactly did he play in the building of Washington DC, the capital of the United States, that he actually participated in the survey work. And so he was using his mathematical abilities not just to do astronomy, but to also participate in what we would probably call now "civil engineering," although I'm super not an expert on the differences between all of the engineering thingies. [laughs] So the other reason that Banneker is notable is because he had an exchange with Thomas Jefferson, about the humanity of Black people. To use today's language he called Jefferson out for being a white supremacist racist, and said: "We are just as human and competent as people like you." And that's the part of Banneker that I think is probably like best-known and best-preserved, in a way. Because he was one of far too few Black people during that time who were not enslaved, and who was educated. He was in a position to do that battle with Jefferson on paper, when um so many of our ancestors weren't allowed to read. So

Banneker is really remembered as the first Black American astronomer. And I think for me, he's a little bit complicated, because I know that he probably wasn't the only one. [laughs] But that's the name that we know. And so I don't mean he's like, I have a problem with him, but it's bittersweet that that's the name that we know, when I know there must have been others.

Emma Byrne 15:58

It's like the preheating/reheating. You *know* there's something there, but the, the evidence is, is beyond, beyond our sight now. Only in this case, that's the fault of people, not just a facet of the physics,

Chanda Prescod-Weinstein 16:14

Right.

Emma Byrne 16:14

The enslavement of people wasn't just an act of economic violence, and human violence, enslaved people weren't just stripped of labour and liberty. You argue about the expertise and the wisdom that was exploited in a time when we are looking at, like, a vaccination rather than inoculation. Would you like to spend a moment setting the record straight about to whom we owe our understanding of inoculation?

Chanda Prescod-Weinstein 16:38

So, at least for those of us who are based in North America, right, and actually, I should say, since I'm at the University of New Hampshire, this is like local, New England information. There was an enslaved man named Onesimus, who introduced smallpox inoculations to the colonisers, who had come to the the Massachusetts colony. I would say he probably saved a lot of lives by introducing inoculation. And it's unlikely that he had come to the idea himself, he was kidnapped in Africa, and so this was knowledge that he brought with him through the Middle Passage. A lot of knowledge came across the Atlantic through the middle passage to the Americas, including the Caribbean. And, and actually - you know, I don't think I touch on this in the book - but one of the misunderstandings that people often have, people of all identities, is that actually the majority of enslaved and kidnapped people went to Latin America and not to the United States. And so, the United States often kind of figures as a central geography in these conversations, but actually, um the majority of people - and this is one of the reasons that I I'm careful to say the Americas - the slave trade didn't have that kind of border, in some sense. Onesimus is important to me because he belonged to the Mather of family, um, and I am a graduate of Mather House at Harvard University. I think I make this as a side comment in the book, but um, I am *not* fond of going to Harvard reunions, but I would go back for a renaming of Mather House to Onesimus House, and I think it would be an important recognition of his scientific contributions, and also Harvard's own legacy and relationship with slavery.

Emma Byrne 18:23

In 'The Disordered Cosmos,' you're passionate about your defense of Mauna Kea. Despite observations that the proposed Thirty Metre Telescope could make possible, you're opposed to its development, even turning down employment that would have meant crossing a picket line. It

made me think what our reaction would be if an international consortium decided to build a radio telescope at Stonehenge, not that the Wiltshire climate is anywhere near appropriate for astronomy! Who's involved in the struggle to prevent the building of this thirty-metre telescope, and what's the outcome that you would like to see?

Chanda Prescod-Weinstein 18:53

I love that comparison to Stonehenge. As someone who has been to Stonehenge, although it was when I was a kid at school in London, and I was like, okay, it's some giant stones right? So on some level, I have an intuition for being so ignorant that you don't have an appreciation for the thing that you're looking at. And of course, now that I'm older, it's I think Stonehenge is very impressive and interesting and all the kind of like the mysteries around it. And so I actually think, you know, it's an interesting parallel to think about in, in the case of like Mauna Kea, because part of the argument is: "this is such an important site to astronomers." And I get it. I haven't been up Mauna Kea, but I've been up Haleakalā, which is on Maui, and is another contested telescope site in Hawaii, and the seeing is incredible. When I say seeing, um, you're above layers of atmosphere that can be disruptive to your astronomical images. I get why it is scientifically compelling, completely understand why it is scientifically compelling. Nonetheless, there are other considerations besides what's scientifically compelling. Maybe part of the comment that I want to make there is that in some sense, astronomers are saying: "this is scientifically compelling for me, and I am therefore emotionally invested in it." And there's this inability to understand that other people could have a different emotional investment in the same place for reasons that actually run deeper than what we find scientifically compelling, and that go beyond our sense of the sublime, which I think is often where scientists are speaking from is our sense of the sublime. But when you're dealing with colonialism, and its aftereffects, you're also dealing with injustice, and pain, and psychosocial heartbreak, right? And I guess I should say that, like my position on this is if the Native Hawaiians decided through whatever process makes sense to them as an Indigenous community that this is exactly what they wanted to do, I'm not opposed to building the telescope, under those conditions. I'm opposed to astronomers becoming a force of divisiveness, where indigenous people are set against each other, because it is in our interests for them to be on one side or the other.

Emma Byrne 21:21

So how was that Georgie, did you enjoy that?

Georgie Codd 21:23

Yes, I did. I loved it. The history, I find the history so fascinating. And also, I've never really thought of the intersection between science and politics. I feel like we should have History of Science as kind of a running along subject at school, because I'm feeling completely clueless about it. And I want to know more.

Emma Byrne 21:46

Yeah, I mean, we are taught, I think, in school, that Science, and certainly the idea of testing your ideas in the face of data, is a really good way of getting over our biases, it's the only way of checking you know, whether or not this is true, or whether we just want it to be true. But who

gets access to the places where the stuff is done? Who gets to publish in journals? Whose names are included on papers? You know, these are all things that are prone to the same political influences, the same social biases as everything else. So there are so many hidden figures in the history of science, and the history of science, the way that scientific institutions suffer from blind spots and biases is something we should be aware of. That said, as Dr. Prescod-Weinstein says, knowing stuff by measuring it is still a phenomenal human endeavour. And that part of science, the way that she talks about retaining her awe and her wonder, in the face of what can be an entirely, you know, an incredibly aggressive or exclusionary area to work, I found very inspiring.

Georgie Codd 23:11

Same here. And are people listening to this bit now? Are they going to be the lucky people who get to hear 'Sh*t I wish I'd Known' for her?

Emma Byrne 23:19

Well that depends on if they are our Patreon backers at Silver Nib and above, because she does talk a lot about the ways in which she works collaboratively, both in science and in writing, and the ways in which she manages to find her narrative voice. So I really think that if you are a backer, you're gonna love this. If you're not a backer, it's not too late. Search for NonFicPod on Patreon.

Georgie Codd 23:45

Yeah, don't miss it. I was enthralled, enthralled by her approach, and kind of delving into the, the way she even handled her acknowledgments section was fascinating.

Emma Byrne 24:01

If you'd like to hear the rest, like we said, get on our Patreon at NonFicPod, and join us at Silver Nib level or above. You also get some nice swag, you get to be in the loop, you get the episodes early, you get to ask us questions directly on our message feed. And also if you sponsor us at higher levels, then you can get a free signed copy of one of our books. And you get to come to some of our amazing live events when we do those, as life gets a little less crazy. And if you really want to help us then what are some of the things that people can do?

Georgie Codd 24:35

You could rate us - that would be super-duper-duper helpful - on whatever podcatching device/implement/website you are using, review us. Just, just be like, best ever, full stop.

Emma Byrne 24:49

Undying love, affection, five star reviews, and maybe a tweet? But yeah, the more people like you who end up listening to us people who love non-fiction and want to know how it's written, or just want to know what is going to be their next brilliant read, do us a favour, and do *them* a favour, and share this podcast with them. That lets us keep bringing you the best writers, and the most exciting new books.

Georgie Codd 25:11

Oh yes, a tweet that would be good! And talking of bringing you the most exciting new books for anyone who has missed it so far, we do have our own online bookshop on bookshop.org.uk. Again, NonFicPod N-O-N-F-I-C-P-O-D. And you can buy the books from all of our authors in the series here. And when you do, you will be making a contribution to the independent bookselling industry, and what's not to like about that? You'll also be helping the podcast so, everyone's a winner, baby.

Emma Byrne 25:44

Absolutely, I promise to not sing as long as you guys come and have a look in our storefront.

Speaking of being a beautiful nerd, I am currently dipping into the 99% invisible city, which is Kurt Kohlstedt and Roman Mars. Roman Mars, the God of silky podcasting voices. And I'm loving it; it's definitely one of those things that you can, like a variety box of chocolates, you just sort of open it and go: "What do I want to know about now? Do a fancy manhole covers today? Or am I going to do the different coloured spray paint markings that I see on pavements? What is it that I'm going to indulge my curiosity in today?" So I'm highly recommending that. Plus it's beautifully made and gorgeously illustrated. What about you Georgie what's on your, what's on your bedside table, or beside your toilet, or wherever you do your books?

Georgie Codd 26:49

I am reading 'I Know Why the Caged Bird Sings' by Maya Angelou. And I have never read any Maya Angelou up until this year, which seems absurd to me now that I'm reading her, because there's something about her writing style. So it's so vivid, it's the first in a series of autobiographies. And it's describing her childhood in in the Deep South of America. And I just, I feel like I'm there, I can smell everything, I can see everything. And it does that thing, which I think fantastic nonfiction books do, which is transports you, and I do feel like I am there, the story just takes you there. And also on a line-by-line level feeling - seeing as we were talking about nerdiness - on a line-by-line level I read again, I'm like: "Oh my goodness, how does she achieved that feeling within me?" I've got about a third left, and I actually don't want it stop. So I'm very glad there are more books out there.

Emma Byrne 27:45

It's a good exercise for our listeners. Um, let us know on the tweets we are NonFicPod three letters, three letters, three letters, all smushed together, no punctuation. Let us know how you experiment with your writing or what kind of writing you particularly enjoy.

This episode of NonFicPod was brought to you by Beatrice Bazell, Emma Byrne, Georgie Codd. Mike Wyer, and our special guest Dr. Chanda Prescod-Weinstein. Our Patreon supporters, are:

Georgie Codd 28:22

Claire and Alexander

Emma Byrne 28:24

David Corney

Georgie Codd 28:26

Alessandra Coyne, which is the best name on the list. Ciao! Ciao!

Emma Byrne 28:31

Nicola Mirams.

Georgie Codd 28:32

Mike Wyer.

Emma Byrne 28:34

Yeah, so if you would like to hear Codd or myself slightly mangle your name in the credits, don't forget to subscribe on Patreon.

We, this, not just the Elgin Marbles, we actually nicked f*cking Stonehenge! [laughs]

Chanda Prescod-Weinstein 28:53

I have to say, you know, the part of me that partly grew up in Kilburn is like: "That is so on-brand!"

Transcribed by <https://otter.ai>