

Numberphile Podcast Transcript

Episode: An A-Class Reject - with Ed Copeland

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He dreamed of being a great cricketer - but his love for equations led Ed Copeland to a career in theoretical physics.

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[Gentle music box music]

Brady Haran [BH]: Professor Ed Copeland is a man who just loves solving equations. Ed's a theoretical physicist at the University of Nottingham, a man I've been making videos with for well over a decade. Now his bread and butter is cosmology, string theory, the early universe, all that good stuff. But in his heart of hearts, Ed loves numbers, mathematics, neatly jotting equations on pieces of paper. You've seen him in some Numberphile videos doing just that. Today he's

gonna tell us about his journey from schoolboy with dreams of playing cricket for England and how doing high school mathematics helped him through a health scare later in life. But first, we talked about Ed's childhood in the Yorkshire town of Huddersfield.

[gentle music box interlude]

BH: What's Huddersfield famous for?

Ed Copeland [EC]: The Industrial Revolution. That was one of the starting places for the Industrial Revolution. Let's see, in terms of if you're a Rugby fan, Rugby League, not Rugby Union, Rugby League began in Huddersfield at the George Hotel.

BH: I did not know that.

EC: Oh yes, absolutely.

BH: Is that where the rules were drawn up?

EC: That's where the rules were drawn up, yep. At the George Hotel. And then of course I suppose then you've got people like Harold Willis, who was a Prime Minister, was born in Huddersfield. James Mason, famous actor, was born in Huddersfield. I used to run to go into school, I used to run through his mum's garden. [chuckles] To get to school I did a shortcut. [laughs]

BH: [chuckles] Okay.

EC: Yeah.

BH: What were you like as a little boy? What was your childhood like?

EC: Oh, very happy.

BH: Yeah?

EC: Very happy childhood. I would just be playing out with friends out... and my parents moved into an estate, a new estate that was being built, so it was still being built when they moved into the house. So as I grew up, when I was four or five, I started playing out on the estate that was still being built.

BH: What amongst all the bulldozers?

EC: Yeah, which is not a great idea, right? And in fact there is a story of me... so I'd be climbing up scaffolding, you know, in the houses that were being built I'd be climbing up the scaffolding and there was one day I climbed up and I slipped and I slipped but the scaffolding went up my jumper...

BH: Yeah? [chuckles]

EC: ... and came out and I'm just dangling there.

BH: [laughs]

EC: [laughs] They had to go and get my dad to come and get me. [laughs]

BH: [laughs] Oh I bet...

EC: I wasn't in a good...

BH: You were in trouble.

EC: I wasn't in the good books then.

BH: No, I bet you'd wish you'd fallen off a house after that. [laughs]

EC: But, we used to play football. A lot of football and then there's a big motorway that goes near where I lived called the M62. When I was growing up they were building it, but they had to blow it out of the ground. I mean so if you've been on the M62 it's blown into the ground, so it's like a valley.

BH: Hmm.

EC: And so we'd get a ten minute warning, you'd hear it, like a siren going. And you had to close all your windows and there'd be explosions and then we'd shoot off. We'd go looking for [laughs] they'd done the explosions and going down into the valley. Partly to go across to another field where there's an even better football field we could play on.

BH: It sounds like you spent your childhood on construction sites.

EC: I was a naughty boy as a child. I've learned my lesson. I mean when I was three, me and Gary Bradley went down... the local postman, in fact the man who owned the local post office he saw us on the main road on our tricycles.

BH: [laughs]

EC: And [laughs] he came out and he said where you going? And we said we're going to Huddersfield, which is four miles down the roadway. [laughs] We were three years old.

BH: [laughs] It sounds like we could do this whole podcast on your childhood misdeeds.

EC: Yeah it had its breaking into houses and all sorts of things.

BH: As you got a little bit older but were still a kid did you have nerdy interests? Were you already on the path to becoming like, you know, a cosmologist, physicist or were you like did you want to be a footballer?

EC: Oh I wanted to be a footballer but yeah I was I think I was thinking about it the other day and when I was at primary school, so that's the school you go to when you're five or so, I remember the teacher giving me and someone called Paul Flynn extra cards which had sums on them. So we'd obviously, I just remember receiving these. The teacher was sort of rather exasperatedly hand them out to us and go and do this, go and do this. So I think I was probably quite keen or I could do bit of sums then, whereas the rest of the class of five, six year olds were doing whatever was in the book. Clearly Paul and I had done this and

we were on to the special cards. So I don't remember having it as I think I want to do numbers as a real youngster but I clearly had some ability, 'cause I do remember getting these cards to do, yeah.

BH: And as you moved through primary school, start of high school what did you want to be when you grow up?

EC: Well, still footballer but I quickly realized, you know, when I was eight I got into the first team, first team [laughs] my junior school's team.

BH: Yeah?

EC: Which were for 11 year olds. So I was doing pretty well.

BH: At football?

EC: Yeah at football. So I was doing pretty well. And then in my final year at primary school. Junior school, when I was about ten or eleven, I scored 31 goals and my dad had said to me at the beginning of the season I'll give you 5p for every goal you score. And the first game I scored seven goals.

BH: [laughs]

EC: [laughs] And he came back, he said we're not doing that anymore. [laughs]

BH: [laughs]

EC: But, I clearly loved football but then I went on to secondary school and I got in the team again but it soon became clear that there were some really good players there who were being selected for the town.

BH: Hmm.

EC: So that to me was the way that you saw it. You could see that they were being asked to go for trials. I had a friend called Chris Sherlock and he played for the town and I thought, yeah you are much better than I am. So that was the end

of my footballing career but then cricket took over and I hadn't really appreciated cricket and at school I started playing cricket. And we were really, we had quite a good team, and we were quite good good, we got into the Final of the Lord's Taverners it was called, the regional final, the Yorkshire final. And the winners of that were the Yorkshire winners and then they would play other county winners and you'd end up at Lord's, the actual final was at Lord's.

BH: Which is for Americans is kind of like the most famous cricket ground in the world.

EC: Oh yeah.

BH: The home of cricket.

EC: It's the home of cricket.

BH: Yeah, mhm mhm.

EC: And so, we reached the final and we played a school called Ampleforth College, which is a very famous public school, well if you're in America a private school, but the grounds, I remember coming across the top of a hill and just seeing everything in front of us and our teacher turning around to us and saying, this is all owned by Ampleforth.

BH: [laughs]

EC: And it had a massive effect on us, we just sort of felt, oh we've had it.
[laughs]

BH: Right.

EC: I think, and we played really poorly and we lost in the final.

BH: Ahh. You didn't get to go on and play at Lord's.

EC: Didn't go to play on Lord's, but I did go then to trials with Yorkshire, when I

was fourteen.

BH: So this is as a fourteen year old, this is a chance to represent the county, which is a big area.

EC: The county, like the area of the state, it's the equivalent of that playing.

BH: And Yorkshire is a real cricket county too, so it's a big deal.

EC: Yeah, yes it was a big one. So I played. I didn't get in the final Yorkshire team, but in the trials we were playing outside and it started raining so we went inside to the nets and in the nets there was two nets there, one had a spin bowler and I was a batter, and I was facing the fast bowler.

BH: And nets is a bit like a batting cage in baseball.

EC: Yes exactly that. Exactly, yeah. I started hitting the fast bowler, and everyone was over on the... all the scouts, all the member's of the Yorkshire board that were selectors. The selectors were over on watching the spinners and then they just gradually started coming over and...

BH: Look at this kid. Look at him!

EC: Yeah! He's hitting. And it turned out the guy I was hitting played for Yorkshire [laughs] in the end.

BH: Right.

EC: And it's the best I've ever done [laughs], it was probably the highlight, me hitting this guy.

BH: Yeah.

EC: And I played a few days later for Huddersfield against a local... another town called Halifax, and about three of them came to watch. But I played really... I opened the batting, I was the number one batter and I opened it and I

got fourteen or fifteen runs before I was out but it took fourteen or fifteen overs.

BH: Right. Slow batting.

EC: Slow, sure batting.

BH: Right.

EC: And they weren't interest in that.

BH: They wanted someone a bit brisker.

EC: They wanted someone that was doing what they were doing in the nets.

BH: [laughs]

EC: I wish I had've had that.

BH: I love how you remember how many goals you scored and how many runs you scored.

EC: Yeah. [laughs]

BH: [laughs]

EC: Yeah maybe the number thing.

BH: I'm like that with my fourteen year old accomplishments in sport. There's seared in my memory.

EC: It's the highlight, right?

BH: So presumably you were eventually coming to a realization you aren't going to be a professional sportsman.

EC: Yeah.

BH: I hope you have come to that realization now. [laughs]

EC: I have. I have. [laughs] I've certainly come to that.

BH: What was plan B?

EC: I guess when I think back I wasn't really thinking about it until 17, 16 or 17, seriously and then by then I knew I was better at maths and physics and the sciences then I was in the arts. Like my English essays were adequate, they were passing exams but I wasn't setting the world on fire.

BH: What did your parents do?

EC: Oh my mum and dad had... my mum was a... she was from Ireland and she was born on a farm and her education ended when she was 13. She had to go back to the farm. She was born in 1933 so being a woman in Ireland, you didn't have much of a [chuckles] chance of higher education, but she was good at maths it turned out. I remember, she's sadly passed away now, but I remember her telling me they realized at the school she was at when she was about 13 that she did have a gift for maths so they put her in a maths class instead of doing the needlework class. So, you know, I tell people I walked around for the rest of my life with holes in my clothes but I could do a bit of maths, so I'd like to think even though she had no formal education beyond 13 that that...

BH: She just had a natural ability.

EC: She had a natural ability. My dad was born in '28, so as with many many people from, you know, working class backgrounds he lived in London in Bow. His dad was a joiner. His education was decimated by the war so he ended up going when he was eleven he went over to Ireland. Evacuated from London, where he stayed for five years. It was a very difficult time because he was in an area of Ireland where there was a lot of anger at the English, shall we say. So he took the brunt of that at school. So he then came back and became a joiner. He trained to be a joiner so his formal education ended sort of when he was 13 as well. And you know you do a lot of practical maths when you're a joiner or a

carpenter.

BH: Mhm.

EC: So he was very practical with the maths. The key thing for me with them was how supportive they were. They knew they wanted me to get an education. It was the thing that they wanted above all. And in particular with dad, in the 1960s and 70s, if you were working on a building site and it was raining, so you couldn't work, that was it, you got no pay, and if you were ill, that was it, you got no pay and I remember him he slipped and fell through a roof twice, so he was badly injured and I remember sitting on his knee, every evening he'd come home and I'd sit on his knee and we'd read the paper together. That was a way of me learning how to read I suppose. I remember one day him saying, for goodness sake get an education. Do not end up in a profession were you're relying on the weather [laughs] to be paid or not. It sort of... I mean I enjoyed doing maths and things anyway but that kind of led me...

BH: Yeah.

EC: ...to think, yeah this is what I need to do.

BH: It's interesting sometimes you were hear stories from children of working class parents who just say, don't be bothering with this education, you gotta get out there and earn money.

EC: Yeah.

BH: And you get this opposite end of the spectrum...

EC: Yeah.

BH: ...where they're like don't do what I'm doing.

EC: It was exactly that.

BH: Hmm.

EC: It was almost a plead don't end up doing what I'm doing. And I've got, the other thing he did, both him and my mum, drove home to me was respect everybody, you know, respect all professions. It wasn't that he wasn't respecting the professions. I mean without builders and you know, he helped build the M1, right? All the bridges that you go under on the M1 around Birmingham, he did them.

BH: Hm.

EC: And he did all the shuttering on them and stuff, but he also knew that there was other things you could do which were just as important and just from a practical standpoint. He said you don't wanna be having to rely on... and it's very hard work...

BH: Mhm.

EC: ...these jobs. You easily get injured on them.

BH: Towards the end of high school, you're obviously it sounds like you're excelling in mathematics and physics.

EC: Yeah, I'm doing alright in maths and physics and chemistry.

BH: So...

EC: The chemistry teacher wanted me to go and do that at A-level, sorry at degree level. But... it was a toss up for me between maths and physics. I really loved maths and I was okay at physics but there was something about maths. I remember hearing about Fermat's Last Theorem and thinking that sounds really easy [laughs].

BH: [laughs]

EC: Why can they not do it? [laughs]

BH: [laughs]

EC: And so I went to the Library. I mean I was about 14 here.

BH: I turned this guy called Wiles who was sitting next to me and said [laughs]

EC: [laughs] I've got an idea. [laughs]

BH: [laughs]

EC: Have you heard of a modular form end group?

BH: [laughs]

EC: No, I've never heard of that, well yeah, here try that.

BH: Yeah.

EC: So I went and I remember thinking, well I'll just I'll do it by a thing I just learned at school which I notice recently you did a Numberphile on an induction, proof by induction.

BH: Hmm.

EC: Surely you can do it by proof by induction. [laughs]

BH: Hmm.

EC: You can't. [laughs]

BH: Well maybe you can.

EC: And they haven't... [laughs]

BH: You can't fit in a margin. [laughs]

EC: Yes. [laughs] But I would go to school, yeah I guess a sign of how much I enjoyed just doing maths was I'd read Scientific American but I'd always go first to the Martin Gardner section and then I ended up buying the Martin Gardner books and I'd go to school and I'd be trying to do the puzzles of Martin Garden whilst I'm sitting on the bus, 'cause I had to get two buses to get to school, so.

BH: Right. You weren't riding your tricycle down the...

EC: Yeah, no I wasn't riding, no those days had gone. Even then I'd realized that was not a good idea.

BH: Okay.

EC: So, yeah.

[short piano interlude]

BH: Just a quick break to say if you're listening to this podcast you may be interested in career paths, maybe your own career. Well, today's episode sponsor is Jane Street. They're a research based trading firm with offices all around the world and they have a hunch that the sort of people who listen to Numberphile might be interested in a career with them. Solving puzzles, cracking problems, all in an exciting international big stakes environment. You could find yourself living in New York, London, perhaps Hong Kong, I know of a few brainy Australians who've actually made the trip over to Hong Kong to join Jane Street, actually. Very exciting place to work, amazing city. Now if you go to their website, that's janestreet.com, and click on the really obvious tab called Join Jane Street, you'll find everything you need to know. They've got jobs listed there, internships, outreach programs they run, stuff about what it's like to work there, any question you've got will be answered there on the webpage. Janestreet.com, check them out and our thanks to them for supporting this podcast. Now, back to our interview with Ed and with a cricket career looking unlikely, what does he do at the end of high school?

[brief piano arpeggio]

EC: Right so I had this tough decision to make, maths or physics and actually it was with my dad said, so I guess the working class... you've gotta have a career at the end of this, I guess he couldn't see a career as such in maths.

BH: He saw physics as a bit more applied?

EC: Yeah, he did, and in fact he...

BH: He didn't know you were gonna become a cosmologist. [laughs]

EC: No, that's right [laughs] that's right. Although when I did my PhD and I was telling him about my first project that I was doing which was trying to find the entropy of black holes, it was trying to what happens if you drop something into a black hole, how does the entropy change and he went and told all of his mates in the pub, my son's working with black holes. And he told me, he said look you just tell me where they are and I'll fill 'em with bricks for you.

BH: [laughs]

EC: [laughs] So, he had sort of felt that I should probably, just for the sake of a career, make sure I go and get something that's do a subject that that's clearly got prospects at the end, and in fact he wanted me to try and get a summer internship type thing. Then get sponsored through university, so I actually applied unsuccessfully to the Atomic Energy Authority to work, you know, at one of their reactors over the summer with the idea that they would then sponsor me through university. But that sort of then geared me towards the physics, so I ended up applying to do physics and let's see, I mean I applied to Oxford and King's and Imperial, Loughborough and I ended up going to King's. Oxford, I wasn't ready for Oxford. You do an entrance exam, I dunno if you still do, I think you still do but I did it in what is called the lower sixth, that's the year before you finish. So I did it early and I remember looking at these questions saying oh I don't know what these are, I can't do this, I can't do that. And I went for interview and they said, how do you think you did? And I said, oh, don't think I did that well, I was struggling on them. They said, you were alright, but you weren't great. And I'm thinking, oh that's me done. And indeed it was me done. But, I'd got from Oxford the most precious thing I've got, is the letter, which they

sent to say, you've not got in, because I'm no ordinary person that hasn't got in, you know, Brady, you're not talking to any old reject here.

BH: Yeah?

EC: I am an A-class reject.

BH: What does that mean?

EC: I don't know, but that's what I am. I have the letter.

BH: The letter says you're an A-class...

EC: [laughs] I'm an A-class reject.

BH: Does that mean you were really close?

EC: Yeah, it meant I was really close. I mean which didn't help [laughs] but...

BH: Do you say every time you win a medal or get some big grant you get that letter out and think, it could've been you Oxford.

EC: [laughs] It could've been you. Yes I'm an A-class reject from there. And then I went to interview at Imperial and King's and...

BH: Not shabby universities. [laughs]

EC: No, they were fine universities.

BH: Yeah.

EC: And, Imperial I went on the Tuesday and King's... no King's on the Tuesday, Imperial on the Wednesday. King's I went to and they said well we only take 25 people, so this is late '70s. Well, now they've closed the department not only to 25 people but they said we take 25, you'll do what they called special physics. That was their degree, special physics. And I really liked, I liked the

people. They said we of course only take in 25, we get to know you all very well. And that was true, that made a big difference. The next day I went to Imperial, they said here's a notice board, and it was this big big notice board, and they said, there's 250 people on there, that's our regular intake, and so it was clear there was a decision to be made, you go for this world class that takes hundreds and hundreds or do you go to this other place which I thought was actually had some great physicists in there as well, and it did, which only take 25, so I went local.

BH: Boutique.

EC: I went boutique, yes. [laughs]

BH: [laughs]

EC: In fact King's is in a fantastic location. I mean it transformed my life. I don't know if you know where King's is, it's on the Strand.

BH: Right.

EC: You must know where it is, it's by Australia House.

BH: Oh yes. I know where Australia House is.

EC: Yeah, yeah. So it's right by Australia House.

BH: Mhm.

EC: And so... but in particular that means it's by Waterloo Bridge. So you go across Waterloo Bridge and you're at the South Bank.

BH: Mhm.

EC: So I'd never been to theater, so I started going to theater. You could get student standby tickets, and you'd get them on the morning and I saw Amadeus, the play, the first performances of Amadeus...

BH: Wow.

EC: I saw. By getting, they held tickets back in the morning, so I'd come in at seven in the morning and started going to the Royal Shakespeare Company, which is in the Aldwych, which was two minutes walk. So what I'd do is I'd just go up to the library and work 'til seven and then go across the bridge.

BH: So from a kid who was playing in the rubble of the motorway...

EC: Yeah.

BH: ...you're now going to see all the highfalutin theater. [laughs]

EC: Yeah, actually you talk about there is on thing I had seen a lot of in Huddersfield. You said what's Huddersfield famous for? It's the Choral Society is a very famous. Huddersfield Choral Society is very famous, so, we'd gone to see Messiah a few times there.

[piano interlude]

BH: How did you find university physics? What was the step up like, and the step up in the mathematics you were doing and...?

EC: Oh it scared the hell out of me. I thought it... [sighs] the first maths class, we were taught maths with engineering and... oh boy, I've got palpitations. So the guy... there were 300 of us there, it was a massive theater and he starts explaining and this letter i keeps appearing. I'm looking at it and I'm thinking well what's this? I'd never come across complex imaginary number.

BH: You didn't do that high school?

EC: No. I'd never done it. Never come across it.

BH: Right.

EC: Square root of minus one.

BH: Hmm.

EC: So I just turned to this person who I didn't know, I said, what is that? He says, square root of minus one and sort of gives me this strange look. And I'm thinking, this is lecture one and so...

BH: What else don't I know? [laughs]

EC: What else... and so I just... in fact what I did was I kinda felt traumatized by this. This is the first class, maths class I've been into and I've got three years, I've just got no chance. [chuckles] But I did, it was a Wednesday afternoon and I walked down the Strand, because about twenty minutes down the Strand is the National Gallery. And I just walked around the National Gallery and it just calmed me down. I just looked at these beautiful paintings in the National Gallery and it calmed me down and I said well okay, you're at university to learn, start learning. [laughs] So I bought all the maths books which I'd been asked to buy, it cost a small fortune, but I'd bought them, and so I turned to the chapter which had an imaginary number in, complex numbers. So, it was hard, I mean I found it hard work. I wasn't someone that it was all just coming natural to and I didn't have to bother with the homework, I could just sort it out. I was working hard, but I did, I was a hard worker. My mum and dad sorta got that into me to, you know, put the hours in and it'll pay off and that's what I did. So the physics came... then eventually the maths came easier than the physics. 'Cause I was good at maths, it's just I hadn't come across this thing, but once I came across it and came across the idea of complex numbers, well A, I was bowled over by and then I was away. I just started enjoying and the physics was more challenging. I mean, you've not only got to the maths, you've got to be able to understand what you're applying it to, the concepts you're applying it to. And yeah, a lot of early university physics, you know, the first year or two, it's things like thermodynamics and classical mechanics, it's the bread and butter of a physics degree, and so, you're just applying things to situations which you might not be that familiar with, you know, most of us never think about what's called a Carnot cycle, the efficiency of a heat engine, unless you're building a fridge or an air pump. But you have to learn all these things and you got the maths, which is

hard enough and then you're trying to make sure you understand the physics aspect, so you've got this double whammy physics. Whereas with the maths, I could just enjoy playing with the numbers and learning it. But when I first arrived I thought, I'm gonna struggle here because my A-levels had been okay but most of the 25 that were in had got straight As on everything, and I hadn't, but I did it. The thing that turned the corner for me when I realized actually I can do this, I'll be okay, was we have, you call them mid-sessionals, you know halfway through the term, halfway through the year you have a set of exams to just see how you're doing and I did pretty well in those exams, and by then I'd got to know a few people, so of course you're comparing how you're doing and I was doing fine, and so I thought, okay, I'm having to work hard but I'm actually doing alright.

BH: You felt like you belonged.

EC: Yeah, I felt like I belonged. And I'd found the football team. I'd got into the King's football team.

BH: Of course.

EC: And I had met a couple of people that were similar to me. They liked the academic side. One guy is now a professor of chemistry at Oxford and so, that meant, you know, I felt really part of it and in the summer I got in the cricket team and so, yeah I felt...

BH: Started thinking, change of career again.

EC: [laughs]

BH: It's not too late.

EC: Not with the football but I wasn't that good. I just hung in there.

BH: At what point do you start being exposed to the things I associate with you now? Cosmology, early universe, string theory, all this crazy stuff?

EC: Not string theory, at this point.

BH: No?

EC: But cosmology, in my third year, not until my third year. There was a course, you know there are these inspirational teachers you're lucky enough to get through your life. At Kings there was one called John Martin. In the year before he taught quantum mechanics to me and I absolutely loved it. I just loved all of this uncertainty [laughs] that was inherent in it, and just solving you know Schroedinger's equations and things for different potentials and different configurations. And then he went on the following year he taught a course in general relativity, it was the first time he taught it, so he was doing it in his own way, and at the end of the course there's a progression that you can take into cosmology. You can use general relativity to sort of develop at a basic level cosmology. And that was my first entry into it, at the end of my third year, and at the same time I was having another set of lectures on statistical mechanics which is kind of the atomic understanding of heat, thermodynamics, at the level of the atom. And, this was a fantastic course that was being taught by another person and I was wondering can I... I knew about quantum mechanics, I'd done statistical mechanics, I'm doing cosmology, and I remember thinking to myself, I'm really enjoying. This was the highlights so far of my degree. I was really just loving learning this complicated stuff and it was blowing me away every time and I thought that's the first time I thought, what can I do, where can I go? How can I carry on? And I don't think I really understood about PhDs at this point and so I began to talk to various lecturers and they said, well you can go and do a PhD. And so I went and looked up where I thought I could do this combination of these and the place that I stumbled across was Newcastle where there was a very famous physicist who'd moved there from King's actually, from the maths department called Paul Davies, who's still very active. Many of your listeners will know about Paul Davies, he's one of the best writers of science communication. He's certainly one of the best science communicators, and he's been doing it since the 70s, writing these fantastic textbooks. He was doing a subject called quantum field theory in curve space, so you had the quantum, and the quantum field theory was bringing in sort of statistical mechanics as well, and then curve space was bringing in the general relativity. And I knew nothing about it, it's a whole topic this, and I knew nothing about it, but I thought, it's

bringing I could see it's bringing these things together. So I applied and he invited me up for interview and so I went, and in those days you couldn't Google anything, right, we're talking 1982.

BH: Hmm.

EC: So I went up to the library and I hunted, there were these big books you could get where you could find out what people had published, and I found his publications and I found a review he'd written and I got from the library got the review and I'm looking at it and frantically taking notes, so that when I went to the interview I was able to say, well I've been reading your review and I learned a little bit about this.

BH: Flattery will get you everywhere. [laughs]

EC: Yeah, I think it just showed keenness.

BH: Yeah.

EC: And, certainly what I tell potential students when they're going for interview, find out about the group you're going to have an interview with. Find out what they do and show that you're interested in what they're doing.

BH: So you aced the interview then?

EC: I aced the interview, and I got it and so then I got my degree and I've been one of these on this production line, right? I've not stopped. [laughs]

BH: [chuckles]

EC: So I'm now... 1982, I'm 21. So I then go up to Newcastle.

BH: That almost seems brave to me, Ed.

EC: Mhm.

BH: That you're going and applying to study something that you don't even know anything about like...

EC: Yeah.

BH: It's a topic you've never even heard of.

EC: I have...

BH: Is it brave or desperate, 'cause you want a job? Like you want the PhD, or is it brave?

EC: I think it was brave in that I felt somewhere inside me that this was what I wanted to do. I didn't... you're right I didn't really understand but I knew at a very superficial level that at university I'd been studying these three topics.

BH: It's like someone told you we've invented a new sport that combines football and cricket...

EC: Yeah.

BH: And you're like, I've never seen it but I wanna play it.

EC: I wanna be part of that.

BH: Yeah.

EC: And so yeah you're right, it's a bit not quite desperation, it's true I only applied for two PhD places, one at King's, to do statistical mechanics which they're very famous for and one at Newcastle and so I was very lucky in that sense. I had thought if that doesn't work, it's the Met Office for me, 'cause I was also we'd had a...

BH: This is the weather.

EC: The weather.

BH: Yeah.

EC: Yes that's right. And we'd had a colloquium from someone from the UK Met Office, the weather people, and it's all differential equations, I mean that's complicated differential equations. It's all chaos, right? It's chaotic.

BH: You could've been a weatherman.

EC: Yeah, I could've been there with Michael Fish and the likes.

BH: Yeah.

EC: But I knew I wanted to do the quantum field theory stuff and learn about so I went up and I started and I had my first meeting with Paul Davies and my subject there's a very famous, in cosmology there's a very famous vacuum, you know, where you've no particles. It's got a name, it's called the Bunch-Davies Vacuum. Davis is Paul Davies, and I didn't had never heard of this vacuum, I didn't know anything about where it would play any role in life but Paul said well, okay, my last two PhD students, he said, they're just here and turned around and he pulled a thesis out for me, he says well this was my previous student and he handed it to me and it was Bunch. It was Bunch's PhD thesis and I'm going and I'm looking and I'm thinking [sighs] no idea. And he said and the current one, the one that's just finished is here, and turned pulled a book out which is called Quantum Field Theory in Curve Space. It is the book of quantum fields in curve space, it's by Birrell and Davies, his other student. And he said what I suggest you do is just start reading Birrell and Davies and then come back and see me, and I'm [laughs] I remember it was one of those feelings again of do I just leave at this point or do I, you know, these are his last two PhD students. One has produced a... the main vacuum in inflationary cosmology, that every has to talk about.

BH: Yeah.

EC: And the other has produced the definitive text book [laughs] on the subject.

BH: Right, what's left.

EC: What's left.

BH: [laughs]

EC: But being naive and not really understanding can be useful so I went off and I started learning. I had to do a lot of it myself. Newcastle is a very small group, Paul had. So there was no MSE courses and no detailed PhD programs which many many, certainly in the US, many universities have. So it's one again where that self discipline has to kick in, right? I didn't know what quantum field theory was, I have to go and find out, so I started looking, I went the library, found books and would spend... I must've spent six months, seven months just reading text books. Not even trying to read papers at this point. Making sure I tried to understand calculations and then eventually Paul said, well, we had tried one project, the thing I'd talked about on black holes, which wasn't panning out and he said, well let's try... his great thing was a thing called particle detectors which is the idea of if you, you know, it's a detector that can detect particles and if you move through a given space-time, what would it pick up? What sort of radiation would it pick up? Would it be a thermal radiation, like a black body spectrum? Would it have some particular distribution that wasn't that. Depends on the space-time and you can do the calculations, thanks to Birrell and Davies. So he suggested a topic, which was to have a detector going in a space-time which was just a two dimensional space-time. The space was just a circle and time was a vertical. So it's a cylinder, right? And it would go up as if you're going up a spiral staircase on a cylinder.

BH: Mhm.

EC: And I had to work out what would a detector see in this. Would it see any radiation or anything. And I remember doing the calculations and I reached the stage where I ended up with this huge huge sum and I'm looking thinking, well I can't do anything with this and then I looked at it with different approaches, maybe three weeks I was spending on it and then one day I'm looking and I had it written out again and I thought, I've got this first term and I've got this second term but the second term cancels the penultimate term and the third term cancels

the one before that and all of a sudden there was this big long expression boiled down to two, which was just the first and the last terms and that was one of the happiest moments [laughs] that I recall.

BH: Breakthrough.

EC: A breakthrough and it was a trivial thing [laughs] if I had written out, but that's what research is like.

BH: Mhm.

EC: You can bang, bang your head against the wall and then all of a sudden something really trivial will pop up and allow you to then progress and...

BH: You seem to spend a lot of your research time like with just a pen and paper like...

EC: Yeah, yeah.

BH: ...really old school like...

EC: Yeah it's the majority of my time, yeah.

BH: And a lot of other academics I speak to talk about sitting at computers and writing code, like that, but you seem to be very old school and you'll just get... you do it incredibly neatly by the way, you've gotten the neatest notes of anyone I've ever seen, but you like actually just that tactile...

EC: I do, I love it. And, you know, I'm happy to write pages and pages, which is probably not the most efficient thing to do. Where, you know, you've got a big long expression and you try and simplify it. And then the next expression still, really long [laughs] and each time you're just trying to simplify it down, so.

BH: But you'll write them out longhand.

EC: I will write them out longhand, yeah, and the only thing that's changed

recently is I guess with iPads, and you know, using something like Notability on an iPad you can now do this wonderful thing where you can cut and paste [laughs] you can sort of copy a bit put it down and then just to edit that little bit, so it quickens it. The downside of that is if you've made a mistake up there it progresses all the way through. But I do use things like Mathematica a lot, but that's gonna be at the level where I've ended up with an expression where I don't think there's much more I can do just on pen and paper. Perhaps I'm having to try and solve a differential equation or something or if there's an integral. But even then I'd first of all try and go to, there's these classical textbooks of integrals and Gradshteyn and Ryzhik and tables of functions. Abramowitz and Stegun, so yeah.

BH: You got your PhD at Newcastle?

EC: I did. I did it. So I worked. So I did this project with Paul.

BH: Were you one of the two... were you as great as those previous two?

EC: No, not quite. I don't think so.

BH: Yeah?

EC: But yeah I did okay.

BH: Yeah.

EC: I did okay to the extent that I did this first project with Paul, and as I said Paul is a great communicator and at that time he was really busy writing books. In fact he wrote a book whilst I was doing a PhD with him called God and the New Physics and from that he won the Templeton Prize. So it's at that level that Paul was, and he went off to write the book in the Lake District which is a beautiful part of Britain of course, but it meant I couldn't communicate with him. But I had a feeling I didn't want to spend my time doing this particle detector and we all have breaks in life, things that go well, you know, we're lucky and my first meeting that I went to, I went in my second year at university and it was to a Royal Society meeting called On Fundamental Constants of Nature, and it was

just a who's who of people. I mean, it was Stephen Hawking, Steven Weinberg, it was Martin Reese. It was just this list of people. And that was the meeting where Hawking said that we'll solve everything by the end of the century because he thought there was this subject called $N = 8$ supergravity, it was all gonna work out and there was only one little missing bit which was understanding the cosmological constant, which was never understood. But there was another guy, Weinberg gave a talk. And, well he's just an inspiration anyway, but he gave a talk and in the talk he started telling us about an idea of extra dimensions. Kaluza-Klein theories and that it's such a beautiful idea that these original ideas are Kaluza and Klein was that the forces of nature that we see, the four forces, electromagnetism, the weak force, the strong force and gravity. We kind of think of them as separate objects, right now, but a goal of theoretical physics is often to unify, and the idea is as you go to higher energies maybe these forces become manifestations of the same force. And in particular maybe eventually it's just gravity and then a way that that was done is by saying the four dimensions of space and time that we see today, maybe we live in a universe that's got more than four dimensions. These are Kaluza-Klein theories, and in that higher space everything is just gravity. It's just the curvature of the space but when you then look at it as a four dimensional universe those extra dimensions manifest themselves as these forces, that's the beautiful idea. And Weinberg had with a guy, another brilliant mathematician called Philip Candelas, who's at Oxford, had come up with a way of looking at these theories and making them quantum. And I thought oh, this is phenomenal, I need to learn about this. And then my next bit of luck was that Newcastle hired someone called David Toms who was working in the subject and I began working with David and the bulk of my PhD was this, and from that I actually got an offer to work with Weinberg. Unfortunately the pound collapsed as its doing again.

BH: Yeah.

EC: And it really collapsed. It went down to a dollar a pound, and I was being paid in pounds so I was gonna get paid about 9000 dollars and I thought, I can't live in Texas on 9000 dollars.

BH: Yeah.

EC: And so I ended up going to Imperial where I hadn't gone as an undergraduate. They'd made me an offer.

BH: This is after your PhD?

EC: After my PhD.

BH: Mhm.

EC: I went to do a postdoc at Imperial. That's where I met Tom Kibble.

BH: Right.

EC: First time, but I'd really been hired by, they have a very brilliant group of people who work on string theory and on Kaluza-Klein models and they had people like Mike Duff and Chris Pope and Kelly Stelle and they made me an offer and I went there, but I actually didn't work anymore on Kaluza-Klein theories. I got there and I started hearing about these weird and wonderful things called cosmic strings and so...

BH: You were seduced by cosmic strings.

EC: I was seduced by cosmic strings and so I started. That was one of the things I began to work on there with Tom and Neil Turok. It is interesting so, you know, how your career path, you are influenced by people and maybe Weinberg isn't... Weinberg's one of those that was he was the influencer, right?

BH: Yeah.

EC: There are those people of course that drive everything and in my eyes Kibble is like a Weinberg, I mean he's a... I think he shoulda got the Noble prize, as you know. [laughs]

BH: Yes. Yes, he passed away now so he can't get it but he was... he very easily could've got one by the sounds of it.

EC: Yeah, and... yeah just listening to him and Neil, Neil also is a good friend of mine and now in Edinburgh who's at the Perimeter as well. He was a very enthusiastic supporter at the time of cosmic strings and I ended up sharing an office with Neil and so his enthusiasm rubbed off on me and we ended up doing a project within a few weeks together.

BH: What are you now? What do I call you? Are you a cosmologist? A theoretical physicist? What do you call yourself?

EC: It depends on the audience that I'm talking to. I call myself more a theoretical physicist, 'cause I like to work on a broad range of topics, some of which will be directly related to cosmology. But you see, cosmology means different things to different people. I think those of us who work on very early universe more speculative ideas whether they're coming from string theory, string cosmology or inflation. I think the hardcore numerical simulators, for example, and observers that are looking at the larger scales of the universe, they don't think of us particularly as cosmologists. [laughs]

BH: No?

EC: They would say they are the cosmologists. Whereas they might put the word early universe, in front of it for us. But basically I'm doing quantum field theory. So I'm a theoretical physicist really. I apply it to gravity.

BH: Without going into the details of this physics that I couldn't possibly understand, I can never quite understand how your job works, from the research. I understand you teach.

EC: Yeah.

BH: You do some teaching as well obviously.

EC: Yeah.

BH: But like, research wise, do you just lie in bed and think, maybe this is how the universe works and then what do you do next?

EC: Not...

BH: Because you can't test it, yeah?

EC: Yeah, no it's very hard to test and that's in fact there's been quite a debate recently, you know, about string theory, right? And testing string theory and I love string theory and I love trying to think about it but it is hard to test something... a theory that is really its action is at very high energy scales and we can't reach those energy scales so what can you do? I don't tend to think, I'll come back to that but I don't tend to think on quite such a grandiose scale of solving some big problem.

BH: Right.

EC: But it'll be more of the case of what do I know about? I know about scalar fields, I know about, because I've worked on inflation, I've worked on Higgs' theories, I've worked on cosmological strings, these all use these things called scalar fields.

BH: Hmm.

EC: And I know what many of their general properties can be and so one approach I've taken is, say with the dark energy, which is, you know, been a big part of my career since about 1998 when it was first sort of realized that something was driving the acceleration of the universe. I knew very early on that it is possible to use these scalar fields to do that because of a thing called inflation, that inflation is an acceleration of the universe, in the very early universe, it's just much much faster rate of expansion than we see today.

BH: Hmm.

EC: So I knew that there was this possibility, so my approach then was to say can I make use of that type of model to explain what is going on today and that led me to what we call dynamical dark energy. So it was a slow process. I began with the idea of, we've got these scalar fields, let's just see whether or not we can have

them so that they're not dominating the universe early on but dominating later on. And I was asking myself what would I have to do for that to occur, and that then led me to kind of build up, it's all in the potential energy... if you want the details what sort of potentials would happen and then having established it could do, then say well what would be the observation consequences. Could we see that?

BH: So it's sort of like you're moving the sliders around and seeing whether or not... it still works.

EC: It precisely that.

BH: Or does the universe break?

EC: It's precisely that, and then also coming in, your moving the sliders around but there's also these buffers. And these buffers are observations, right?

BH: Right.

EC: These buffers are things that say...

BH: Reality checks.

EC: Yeah they're too... yeah that's right and I'm always hitting the buffers, that's the problem. Always seem to be very close to the buffers anyway that so you're moving a parameter of the model, changing some variable.

BH: Hmm.

EC: So that it can fit but you find that by doing it it's then leading your new universe that you're creating to violate something else and some other energy scale maybe. Usually to do with the cosmic microwave background which is sort of tightly constrained. So it is that balance that you're trying to find, the path through.

BH: Mhm.

EC: Of course but I have to accept that I don't know what the underlying theory. I do not know what nature has provided as the underlying theory and I'm sort of playing around with various models.

BH: So this is what it sounds like to me. Tell me if I'm wrong. You're twiddling a bunch of dials, all these different dials.

EC: Mhm.

BH: And finding out what configuration of dials would match what we observe in the universe and if you can get all the dials on the right numbers and it matches what we see in the universe you may have figured out how the universe works but then maybe someone could come to you and say, well that's nice Ed but I've got some bad news for you, that dial doesn't actually exist.

EC: So... I'd agree with you up to the point of me saying you've found out how the universe works. It's always a model that you're dealing with.

BH: Hmm.

EC: What you'd then be trying to do is understand, so what you would then do with say that type of... you'd say what are the characteristics of this model that's allowed it to work.

BH: Hmm.

EC: Can I embed that in what you would hope is a more fundamental theory. Like a string theory, which is, you know, or another theory of quantum gravity. That's where I would go.

BH: Hmm.

EC: That's where I do go. I then try and say given that, does it fit in to a more fundamental underlying theory.

BH: Like, do the dials exist?

EC: Which then means do the dials exist, yeah. If it doesn't fit in to that theory then at least coming out of that theory those dials don't exist. Letting parameters vary is like turning a dial, it's exactly that. And this is what they're doing, for example, in, you may have heard when they're searching for the axion as a dark matter particle, they're literally turning a dial in their case, it's a dial which can tune into different frequencies. But what they're effectively testing is the different parameters on the axion model by seeing that these frequencies corresponding to changing these parameters and when if it was to pick up a signal then it is telling you something about what that value of what that parameter is.

BH: How advanced mathematics do you have to use? Like would mathematicians look at what you're doing and think oh that's child's play, or is it quite advanced math?

EC: No they'd say it's... I mean... it's child's play for a proper mathematician, right? I have tried reading proper mathematics, you know, and I can't read them. No, I'm doing the... the mathematics I'm doing is good, I think, I mean I hope it's good. I'm solving some complicated systems and I'm using approaches which are quite demanding. I'm quite often, in fact, in almost all the systems that I look at, you can't solve them exactly. You need some approximation schemes and so you're having to develop either perturbative schemes or some schemes which allow you to figure out what's the main contribution to something. These are quite complicated mathematics and well know techniques but they're not at the level of dealing with some of the pure mathematics that you see having to go into solving some of the prime number conjectures for example.

[genetle piano interlude]

BH: How do you come up with new ideas, personally? Have you got a thing you do? Do you like to go for a walk in the woods or have a shower or?

EC: We've just been doing interviews and that was the question that we ask, actually. How do you decide on what project to work on. That was a question we

asked. And it's really hard. In fact as we were asking I'm thinking, what do I do? I think it's a combination of things. Sometimes like I said when I went to Imperial and I got talking to Neil and Tom and I just got bowled over by this idea. At the time as it happens with the cosmic strings they were, it really looked like they could be telling us something about the distribution of large scale structure and yet there was so little known about their dynamics and so I think what deep down I think that's just made me realize, I think deep down I like to see an equation that I can solve. I love maths. I love solving equations and I like to be able to hang the maths onto some physics but I love to see what the actual underlying equations are and if I like the look of it I will often just go for it. It doesn't necessarily mean that I'm gonna try and solve how the universe is behaving at the moment. I just love solving equations, so I think the beauty of the maths often grabs me, that certainly did with things like the strings and he has done with all the early universe things I do. It's not usually the case that I hear of an observation and I think I want to explain the observation. I don't work like that. I'm...

BH: You won't see some new picture from the JWST...

EC: Yeah.

BH: ...and think, Oh, I'm gonna come up with a way...

EC: No. No. I'm not as brave, I think, as that, or as fool-hardy perhaps to sort of say, right, I'm clearly gonna have to totally rethink this and just let's just try this total new thing. No, I tend stick more closely to the areas that I've been working in. And I've been working here long enough now that there's quite a few of those areas. There's always interesting things to think about and given that there's these areas that I'm interested in within those areas I just... I think it's true, I'm just thinking on my feet, sitting here, right now, wondering about it. I think it really is the elegance of the equations that grab me. I love to solve an equation.

BH: What do you do when you have like a block, though? Have you got like just in your personal life? If the ideas aren't flowing or something, have you got a thing you do?

EC: Well one of the beauties of being a lecturer is you have to do other things. You've no choice. And I love teaching. I love... communicating science. And I do it in teaching as well, I do silly things in the teaching, you know. In lockdown where we all, everyone's had to go do videos. Well, I brought teddies into my videos. So there was an audience there and I talked to the teddies.

BH: [chuckles]

EC: And that worked. We just had graduation, a few weeks ago, here and the number of students that came up and said how much they enjoyed that interaction that I was having with teddies. [chuckles]

BH: Were the teddies on camera or behind the camera?

EC: Yeah, no, no, they were on camera.

BH: So you were like talking to them in front of the camera, like?

EC: Yeah, so I had...

BH: They must've thought you were bonkers.

EC: Yeah exactly.

BH: [laughs]

EC: The best one I had a different teddy for each of the lectures.

BH: Were you calling them like Ted-Ed? Or what ever you calling your [laughs]

EC: Yeah, they all had names. The horsey, they all had names.

BH: Okay.

EC: And then for the final lecture of the mechanics course, for the final lecture I brought them all in.

BH: Right.

EC: So I set up like a little lecture theater and they were all there. But what I made use of them to actually bring across a point. I'd turn to them and say, what was that, is the Hamiltonian conserved in this system? That's a good point.

BH: Right.

EC: And so it would just, you know...

BH: Yeah.

EC: It was a way of breaking... it relates to you, what do you do when you're a bit stuck. You've got to teach.

BH: Right.

EC: And so sometimes I put huge effort into the teaching side or, you know, we have to do our administrative roles. I was head of outreach here for a while and so you do that. So those things you have to do but some people only have one project on at a time. Maybe two projects, you know, so I imagine Andrew Wiles had that one project, right?

BH: Hmm.

EC: I think he did, seven years. I can't do that. I have got maybe four or five things, so I will flit between them. I don't like working by myself very much. I have done it. I love collaborating with people, so I love the chance to be able to interact with... so if there's a block somewhere I will quite often go and think about something else. Either it might be teaching, or I'll go and think about another project. I mean we do go for walks, of course we do.

BH: Hmm.

EC: But I don't tend to think that I'm gonna go for a walk now to clear my head

and sort this out.

BH: Do you ever worry like, you know, you're not an old man.

EC: Hmm.

BH: But you're also not as young as you once were.

EC: Mmm.

BH: Do you ever worry you're running out of time and you wanna discover more stuff and find out more stuff, and you talk about having all these different projects on the go, plus you gotta teach, plus you gotta that and you got, do you ever think, oh no I want more time, I want to do more stuff.

EC: I have entered the period where I think I want to enjoy it. What I'm doing, I really want to enjoy. So it hasn't gone that way where I feel like I need to do more and more and more.

BH: Hmm.

EC: But I have thought you've gotta be more selective. One of the downsides of doing lots of projects is you could ask yourself how selective are you being on when you say to someone, yeah that'd be fun to work on.

BH: Hmm.

EC: So I've definitely moved into a thing which is sort of recognizing the finiteness of how long you've got left, of what you're gonna work on. Yeah, so rather than saying no I'm running out of time, I've gotta do this big thing, it's more that I've gotta make sure I enjoy it.

BH: Does enjoying it mean picking the right topics or picking the right people?

EC: Both.

BH: Hmm.

EC: Both. Definitely picking the right people to work with. I mean one of the things I like most about being here is, you know, when I came here it was a major consideration when we were making appointments is would we get on. Would there be a group here where people felt they enjoyed each other's company? And I think it works really well when that happens. It fosters a feeling of trust and of collaboration and it's a nice environment to be in.

BH: Do you wish... I'm thinking back to that fork in the road where you chose between physics and mathematics and your dad said, ah go physics.

EC: Mhm.

BH: Do you ever wonder what the maths fork would've been like?

EC: Yeah, I do. I do. I've often wondered what would've happened and I fear I wouldn't have been good enough. I don't know, of course I don't know. And I know that I work very hard so I probably would've been okay. I have a feeling I've reached... I did the right thing in that I'm doing... I think I'm doing pretty good things in the area of cosmology that I work in, I hope I am anyway and making inroads. I have a feeling that if I had decided... you know I'd have been doing prime numbers. There's no question. That was the only thing I really cared about.

BH: Yeah?

EC: I have a feeling I would've been a... you know someone, churning away not making, not being anywhere near being able to do the prime conjecture, you know Twin Prime Conjecture or anything like that, or Riemann, which is of course is the big holy grail. But I don't know. But I do often think back.

BH: Hmm.

EC: And it's the out of the videos, the Numberphile videos, I always go if I see that you've done a Numberphile. Well I always watch the Numberphile videos.

BH: [chuckles]

EC: I've been in some of them. If I see you've done one on prime, I'm straight there.

BH: You like the prime number ones? You're the lone ranger there.

EC: Yeah, no, I know.

[gentle piano interlude]

EC: You know, maths has played a big role in my life and in ways which I wasn't expected, so around 2009, my dad... well early 2000s my mum sadly got Alzheimers and she had to live without Alzheimers and passed away in 2013. But my dad was looking after my mum until about 2009 when he himself was feeling unwell and then it turned out because he was a builder, he'd worked all of his life on building sites. In the 1950s and 60s asbestos was used, all the time. He was cutting up asbestos. He was sweeping up, particularly in sweeping it up at the end of the day. And it turned he'd gotten a thing called mesothelioma, which is very very nasty cancer of the lining of the lungs. He stayed with us at home for the last six months in 2009 and then my mum was in care home, and he was in a lot of pain and we were really struggling to get the pain relief sorted out and anyway, we did eventually it was very as happy as those situations can be, he was really pleased to be with us and we were delighted to have him and he could go see my mum and so could I. And then a few years later, so he passed away in 2009, and now we're about 2012 and my daughter's about to do her A-levels. So here comes the maths.

BH: This is the high school.

EC: She's at high school. So these are the exams you do which if you pass these exams you go on to university.

BH: Big deal for kids.

EC: They're a huge deal.

BH: Yeah. Yeah.

EC: And, so she was doing maths and further maths it's called, so two maths courses. And something really weird started happening to me. I began to feel a pain in my lungs, and it was the precise spot where my dad said he had been receiving this pain. And it is the most bizarre mental thing that you're going through. 'Cause you're thinking this can't be right. There's nothing with me, I'm absolutely fine. But of course I'm thinking back to my dad, 'cause we lived with it, and this huge problem and the pain that he was having. And I'm feeling it and saying no, and I'm moving thinking it'll go and I'd move and it'll go. But then I'd feel it again, so eventually, it had quite an impact on me. I found myself unable to concentrate. You know, I'd come to work, it was I'd be coming to work and I wouldn't be able to concentrate, I'd be kind of looking out for it at this point. And the thing that eventually kinda started working for me was Hannah, my daughter, said would I help with some of the maths. And so, I literally spent hours, and I wasn't doing it for her, really, I mean I was in that...

BH: Sort of tutoring her and helping her with her...

EC: Yeah, but, the level of tutoring I was doing, I went through every maths problem.

BH: Yeah? [laughs]

EC: She didn't want them. She'd done them. She was very smart, she ended up at Cambridge. She got straight A stars, she didn't need me.

BH: Mhm.

EC: I needed her and that maths.

BH: Yeah.

EC: You know, I was doing them and they were taking up... that was what I was

able to concentrate on just sort of thinking about... partly because I was felt I was probably helping here on some occasions I was but also it was just something I was familiar with and I could do and...

BH: Cathartic.

EC: Cathartic and I ended up whilst I was doing this eventually I told, you know, Natalie, my wife, who you know, and she said look, I'm absolutely sure you're fine but why don't you go to the GP and I went to the GP.

BH: Oh typical, you haven't gone to the GP yet. Typical man.

EC: No, no. Typical man.

BH: Typical Yorkshireman. [laughs]

EC: Yeah, yeah. And so I went and the GP said, I'm absolutely sure you're fine but I can see you're concerned, let's send you off for an Xray. So I went off to the local hospital. This is 2012, it's the olympic year.

BH: Mhm.

EC: Okay? So that's relevant. I went to the hospital, I did an Xray and then I'm putting my shirt back on, and they said, um would you just come back in. And, you know, I'm going, oh my god, they've seen something and they just want to... and they said, you've got really long lungs. [laughs]

BH: [laughs]

EC: And I said, oh yeah, right, you're just being kind to me. And so I went back in and they moved it slightly and took another picture and they said that's it. And...

BH: So the first one they hadn't got your whole lung 'cause it was long?

EC: That's what it turned out to be, yeah. They genuinely hadn't got it all.

BH: Yeah.

EC: But I didn't believe that.

BH: Right. [laughs]

EC: In my head, they'd seen it.

BH: Yeah, yeah of course.

EC: Right, they'd definitely seen it, it was there, and they were just homing in. And then I went through the most bizarre sort of justification of timeline that I've ever done. I couldn't literally go back to the car because as I said, it was the Olympic year, and if you remember during an Olympic year the torch goes through the towns of the host country.

BH: Yes, the torch relay.

EC: And it happened to be Newark's today.

BH: Right.

EC: And they'd shut the road off which allowed me to go across to the carpark, so I had to come out of the hospital and just wait. And I had to wait for an hour.

BH: For this convoy to go by.

EC: For this convoy to go where there very happy people waiting for the torch with some local celebrity coming running along with the torch.

BH: Hmm.

EC: And I'm going in my head, I'm going, okay they've not contacting me for ten minutes, so, now they've not contacting for twenty... so I'm okay. Gradually convincing myself I was alright.

BH: Hmm.

EC: And then by the time I was released to go I had totally convinced myself must be totally wrong, an hour had gone okay they're not that worried, they've not called me back.

BH: Right.

EC: And then, you know, the week later I got called into the GP, he said you've got really long lungs. [laughs]

BH: [laughs]

EC: By the way, there's nothing there.

BH: Nothing there? What was it, just in your head or was it?

EC: It was all in my head.

BH: Yeah.

EC: It was all in my head, and but there had been this period of about, I'd say a week where I was just doing the maths with Hannah.

BH: High school, high school maths.

EC: High school maths. And it was I don't know if she realizes that it was a sort of saving grace in the sense that it took my mind off this thing that doesn't exist. I mean I've never experienced it before and I've not experienced it since this where you can't get it out of your head. So now when somebody says to me, you know they feel something, I believe them.

BH: Hmm. You tell 'em to go do some high school maths.

EC: [laughs] Yes, I will do. Yeah.

BH: One question of that though you were telling me you didn't do complex numbers at high school.

EC: No, yeah.

BH: What was it like for you going back years and years and years later looking at what high school students are learning now?

EC: Actually I was pleasantly surprised about the maths course, and in particular what's called the further maths course. The maths course does do complex numbers now. And the further maths course does some really quite quite neat stuff. Matrices, and eigenvalues and a lot more detail of complex numbers. They do a lot of DeMoivre Theorem, really dealing with some fairly detailed calculations and in fact they actually do differential equations. It's much better than the maths course I did. I mean I did okay in the maths, it turned out my A-levels, I was clearly reasonably good and they put me forward for an extra exam called an S-level, which at the time was beyond A-level and very few people took it. And it's one of these one exams where I couldn't answer a single question completely, but I got an A from it because I'd clearly... I mean I loved that paper, even though I knew I couldn't answer the challenge of trying to do angle formulas and things was there but there was no complex numbers in it 'cause I didn't even know they existed, it was really strange.

BH: Well, do they exist? They're imaginary.

EC: Well, exactly.

BH: [laughs]

EC: Wherever the hell are they.

BH: One more question.

EC: Hmm?

BH: You've written lots of great papers and won medals and worked with amazing people and...

EC: Yeah.

BH: ...amazing friendships. Would you swap all of that success and that career to be a test cricketer for England?

EC: Yeah, to be a test cricketer? Yeah.

BH: Yeah.

EC: Not particularly a footballer, but a test cricketer.

BH: Yeah, you'd swap?

EC: To... and to be at the MCC, to be MCG in Melbourne.

BH: Yeah? Play at the MCG. You don't wanna play at the MCG with a 100,000 Australians baying for you blood.

EC: Absolutely. And smack them all around the ground. I mean.

BH: [laughs]

EC: [laughs] One of the great memories I've got of is it the Centenary Test? Are you old enough to remember the Centenary Test?

BH: I was only one when it happened but I'm very familiar with it. Test cricket is like international cricket play between the countries, and the first ever match was between Australia and England in 1877, and then they played another test match, a special match in 1977 called the Centenary Test.

EC: Yeah. That was a game and a half. And of course I was... it was in Australia.

BH: And, Australia won by 45 runs. The exact same margin as the first test.

EC: You have no need for that.

BH: [laughs]

EC: No, need for that. But [laughs] I was under the blankets. It was nighttime for me.

BH: Yeah.

EC: And they were broadcasting on the radio and the thing I remember was Derek Randall. I mean if got Derek Randall, who's Nottinghamshire.

BH: Hmm.

EC: And I met Derek Randall.

BH: He was a batsman for England.

EC: He was, and a super fielder.

BH: Mhm.

EC: Super, super fielder. And I met him at John Lewis, the local store, he was buying a coffee and I went up to... and he had a great game, he got a hundred plus.

BH: Mhm, mhm.

EC: And it was that innings, I would love to have done that innings.

BH: Mhm.

EC: And I went up to him actually, it was about just about four years ago. I just saw him there and I thought, I've gotta go and say thank you. I mean what else can I do, so I did, I went up and said thank you for everything and in particular

that Centenary Test. And he was bowled over there.

BH: Yeah?

EC: 'Cause, you know, you reach a stage and people forget and...

BH: Yeah, yeah.

EC: Yeah, it was great.

BH: You didn't even pause when I asked you if you'd swap your career to be a test cricketer. [laughs]

EC: [laughs]

BH: You said yes before I finished the question.

EC: Cricket, I love, cricket.

BH: It's a good game.

EC: It's a good game. It's an absolute cracker of a game.

[gentle piano outro fades in]

BH: That's all for today, thanks to Ed Copeland for sharing his time and thanks to Jane Street for sponsoring this episode. More links to Ed's work and his long list of videos we've made together will be in all the usual places. I'm Brady Haran and you've been listening to the Numberphile podcast.

[music cuts out]