Numberphile Podcast Transcript

Episode: A Chain of Chance - with Michael Merrifield

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[Gentle intro music]

Brady Haran [BH]: Today I'm speaking with Professor Mike Merrifield. He's an astronomer at the University of Nottingham. I've been filming and interviewing Mike for something like 14 years, I think. He's a mainstay of my channels Sixty Symbols and Deep Sky Videos and he's also cameoed here on Numberphile in the past. Like so many scientists, his career path is really fascinating to me. And in this discussion I learn many things about Mike I didn't know before, so prepare for a meandering discussion about submarines, judo and the benefits of having terrible handwriting.

[Piano music]

Mike Merrifield [MM]: I was born at a place called Bexleyheath in Kent, so just outside London.

BH: Just outside London, like in a hospital or…

MM: Bexley Maternity Hospital if you want the more precise coordinates. [chuckles]

BH: And this here's a question, what day of the week were you born, do you know?

MM: I'm sure I used to know. I think it was a Wednesday, but I'm not entirely sure.

BH: Okay, we'll research that later. That can be one to check later. What were you like as a little boy? What were you into?

MM: How old do you want to go? How small?

BH: Like, you know, toddler, primary school, like what were you into? Did you… were you really into sport, were you really into nerdy stuff then, or?

MM: I don't think I was really into anything, which is a bit sad, but I was just… I don't have that many memories of being a kid. At least as a small kid. And you know I remember playing with stuff and I remember I had a little wooden engine I used to like driving up and down the garden and those kind of stuff but I don't really remember that much about being, you know, so we moved from Bexleyheath when I was four, maybe. And so actually it was kind of, that was very early stuff and I don't have that many memories of that first house at all.

BH: What did you parents do?

MM: So my dad was a museum curator, worked in am museum, and my mum was a housewife at the time.

BH: So if you've got a father who's a museum curator, you're obviously surrounded by some pretty interesting stuff and curios. Did that inform you at all? Do you have memories of running around museums and looking at cool old stuff and…?

MM: No. [laughs] Isn't it tragic? No. I remember there being sort of sometimes there was stuff around the house and you know like, stuff that would fill people with horror these days, like my dad had a few swords lying around and those kinds of things. But, no, it really didn't impact much upon me.

BH: Ralpj was your father?

MM: Yep. [laughs]

BH: He was quite notable in his field.

MM: He was, yes. I mean, he was, you know, he was a senior figure in archaeology. He's sort of credited having invented rescue archaeology. This thing whereby when a builder's about to to build something there's a requirement that the archaeologists get to the go in first. So he was kind of for many years he was hated figure in the building profession, because, you know, they don't like the fact that they have to get delayed by waiting for the archaeologists to do their thing. But because he was… this was I guess the 1960s and there was a huge amount of building going on in the City of London. And the City of London was kind of his area. And so he was really pushing for there to be a lot of archaeology done, you know, before these new buildings were going up. Just to see what was there before it was covered up forever. So he's a big figure in that and later in his career there was this kind of paradigm shift in archaeology that he was largely responsible for which is that at the time people thought, you know, whenever you found anything in archaeology they'd always try and find a rational explanation from it. And his argument was, very often there isn't a rational explanation, that quite often things are done for ritual reasons. That there's actually you know, some quasi-religious or ritual thing that you're doing.

BH: Can you give an example?

MM: So for example… the classic example of this is shoes under floors. Old shoes found under floors. Quite often when you're renovating an old house you'll find there are shoes under the floor. The rational explanation is well somebody lost a shoe. But, actually it doesn't really hold water because, you know, if you lost a shoe you're not gonna replace the floor boards before checking whether there's a shoe underneath it, right? And so nowadays the generally accepted explanation is it's a kind of ritual thing. That there's some kind of you're making some kind of deposit to some god or other and that's the reason why very often when you look in an old house now you'll find shoes hidden behind walls or under floors.

BH: So I imagining archaeology loomed reasonably large in your life. Was it

something that interested you at all as a youngster?

MM: I'm sounding awful in all of this but, no it all just went way over my head. I wasn't that, you know, into it at all and you know my father was kind of an old school kind of person in, you know, he'd do his work at work and then he'd come home and, you know, dig the garden and do all those other things that he'd like doing. And so actually he didn't actually bring his work home that much with him.

BH: So as you started to get older then and started to develop your own interests and personality and strengths and weaknesses what would you have wanted. If I went back in time and asked you want you wanted to be when you grew up what would you have said to me?

MM: Um… well at an early age I wouldn't have a clue. When I was sort of early teens I wanted to join the Navy. I wanted to be a submariner, for again reasons which now escape me entirely.

BH: I never knew this about you.

MM: Yeah! I really wanted to be a submariner, and it turned out they wouldn't have me because so I wanted to be an officer in a submarine, right, I wanted to be a captain of a submarine. Turns out bizarrely all officers in submarines are watch-keeping officers, and at the time there was a requirement to that to be a watch-keeping officer in a Navy ship, you needed to have 20/20 uncorrected vision, which I didn't have. Which is bizarre in a submarine, right, which spends most of it's time not able to see anything at all but it just was the rule, and so that kind of career path was probably providentially cut off. [chuckles] And so I didn't actually pursue it.

BH: What's a watch-keeping officer?

MM: Somebody… so there in the Navy there are engineering officers, right? There are people who are just like, you know, in charge of the engines, or there are gunnery officers who are in charge the armaments. A watch-keeping officer is one of the ones who kind of takes control of the ship, and so actually has to kind

of you know be able to see what's coming the other way.

BH: So you had gotten to a point where you were thinking of applying, or had you already been told before you even went down this path, forget it, because of the vision thing?

MM: Yeah, no, I never actually applied. So I was a Navy cadet when I was at school. So we had the cadets at school and so I was in the Navy section of the cadets, mainly 'cause I liked sailing. And we did a few things, you know, we went sea training and we got to go round a few nuclear submarines and things so I got quite interested in it then. And I did… I must of pursued it as far as finding out that they wouldn't have me but that was as far as I went with it.

BH: Do you still have an itch for submarines? Do you watch the Hunt for Red October and think about what might have been and stuff like that?

MM: I kind of enjoy… I mean why was it submarines appeal… I think it's just because it's this very sort of self-contained society. And I think that just really appealed to me, this idea that you got this kind of microcosm of a society without all the complications and confusion of the big bad world most of the time.

BH: You couldn't have gone further from being under the ocean to looking at galaxies. [laughs]

MM: It really was completely the opposite direction, yeah, absolutely.

BH: So, what were you good at and what were you into as a sort of teenager in high school?

MM: I was kind of… I was okay across the board. I went to a really bad primary school, like an awful primary school, which I won't name [laughs] because I don't want to get sued. And actually to be fair, I did actually just out of interest look up its latest reports and its now an extremely good primary school. But at the time it was awful. And the reason why it was awful so this was… I started there in the very late 1960s and the teachers were kind of products of the 1960s

and had this view that, you know, that you should just let kids be kids and you shouldn't make them do stuff and you shouldn't ever tell them that they're wrong. And so that means that fairly basic things like learning my times tables and learning handwriting I never did. And so I came out of primary school with illegible handwriting and not really knowing how to do arithmetic. I managed just about to scrape my way into a pretty good secondary school and I kind of started kind of low down in that secondary school just because of this sort of start in life and I kind of clawed things back a bit, but by the time I got to sixteen, so then there were these things called O-levels that you did when you were sixteen. I did pretty well across the board by that point and at that point in the UK education system you have to make this decision essentially 'cause you cut down from the, you know, ten or so subjects that you're doing down to three, basically, three or four subjects. And so you really at that point make a decision, do you want to do the humanities or the sciences, which is crazy. So it's completely daft but what made this decision for me, essentially, was well, you know, I could go the humanities route or the sciences route. The humanities route I end up having to write lots of essays. The sciences route I'd end up doing lots of maths, but the thing that had changed in between primary school and secondary school is the pocket calculator had come along. So actually my inability to multiply two numbers together was no longer really that much of a problem because you just plug it into the calculator. Whereas, you know, the word processor was still many years in the future so actually I would've been handwriting essays. So fundamentally the reason why I ended up doing sciences is because I went to such a bad primary school that it kind of shut off the humanities really because no one would be able to read my writing when I wrote the essays.

BH: Was it that illegible that you couldn't read it? Or was it hard for you to do it? Was it a chore to write?

MM: It was more that… I mean it was somewhere in between the two, right? My handwriting at its best is hard to read and it's a real pain to write and so actually I just couldn't face the idea of sort of spending the next several years, basically spending all my time trying to write stuff which I found painful to do anyway.

BH: But did you enjoy those subjects? Did you like the idea of studying history

or… the humanities' subjects or…?

MM: I really did actually. I enjoyed… so yeah which subjects did I particularly enjoy? I guess English I really enjoyed. I enjoyed creative writing. So I really enjoyed English. I didn't enjoy history, so I gave up history at the earliest stage I could which is probably again, just reacting against family type stuff. But yeah, English I really enjoyed. Languages I enjoyed, and I enjoyed the maths and physics side as well. So the two subjects I did badly in, at O-level were chemistry, which I've never had much time for [chuckles] and particularly at O-level because so much of it was just about memorizing stuff and just sort of rote learning. It was frustrating because they tell you, you know, this is how the periodic table's arranged. And you wanted to know why, right? Well that's not on the O-level syllabus, you know, and so actually it was sort of a frustrating subject. So chemistry was one I did badly in. The other one I did badly in was English literature. And that probably was partly the handwriting thing but also partly because, so I'd done quite well in most of the… we had lots of kind of assessed elements but there was an exam as well. The exam was mostly on Romeo and Juliet.

BH: Right?

MM: My contempt for the play Romeo and Juliet knows no bounds. And I have a bad feeling that that probably kind of came through in the essay [laughs] that I wrote for my O-level. 'Cause I really didn't like the play.

BH: Okay. Alright [laughs] well that sounds like a whole other podcast, Mike Merrifield dissects Romeo and Juliet.

MM: [laughs]

BH: What were you thinking about a career though, you must've been getting to a point where you start imaging, oh what am I gonna do when I'm and adult, like, did you have a dream then now that submarines were off the table?

MM: I probably didn't that much, I was sort of following my nose. I was quite into computers as well at that point so I guess I was, you know, on computers,

this was, so now we're talking about very early 1980s and at that point computers were just really the thing that was coming up and one of the A-levels I took was actually in computer science so I was actually, you know, quite into the whole side of things, so I guess I probably had it in the back of my mind that there was probably a career in computing if I wanted it.

BH: What did you know or think of astronomy at that point?

MM: Nothing. [laughs] My dad did actually buy, you know, one of these mail order very cheap telescopes at some point, 'cause I remember us being out in the back garden, you know, looking at Saturn and seeing the rings of Saturn in a back garden in the middle of London at that point. But I really didn't have that much to do with astronomy at that point.

BH: What was your first job?

MM: [laughs] I was a judo instructor.

BH: You were a judo instructor?

MM: [laughs] My first ever job.

BH: How old were you then?

MM: I was nineteen.

BH: So, were you at university then?

MM: So I was at university, this was a summer job.

BH: Right.

MM: So I got a summer job.

BH: You obviously had already been doing judo before this actually?

MM: Yeah, so I did judo. I started judo when I was about ten I guess.

BH: Yeah?

MM: I was, you know, I was sort of average at it. You know, they have these colored belts. So I got as far as blue belt.

BH: Okay.

MM: You know, it goes blue, brown, black. So I was kind of, you know…

BH: Two down.

MM: A fair way towards the top. And I kind of enjoyed doing it and I wanted a summer job. Actually one of the other aspects of my life we hadn't talked about is when I was a kid my parents and I decided quite early on that our idea of what constituted a holiday was different in that they liked going around ancient monuments and things and, you know, when I was kid I didn't really. So we sort of parted company on holidays and they'd go off and visit ancient Rome and I'd go on one of these kids unaccompanied holidays. And I learned to sail and canoe and do all those other things you'd do on those adventure holidays and had a complete blast. And 'cause the great thing about them is you kind of get to completely reinvent yourself. 'Cause nobody there knows you, and so you kind of, you know, be whoever you want to be for a couple of weeks. So every year I'd go off on one of these and be a cool kid for a couple of weeks.

BH: [laughs] Right.

MM: And I got really into them and really enjoyed them and actually it turned out that it leaked back into my real life in that one year I was there being the cool kid and somebody I knew from school turned up, quite coincidentally. And I was thinking of sh-t that's gonna blow it.

BH: [laughs]

MM: And fortunately he didn't, right? And actually I was the cool kid for the

week.

BH: Right.

MM: And when I got back to school he told everyone, yeah, you know, what… [laughs]

BH: Mike's pretty cool.

MM: He's pretty cool.

BH: Yeah.

MM: He gets the girls and everything.

BH: [laughs]

MM: So anyway I got really into them and so when I was at university I thought well what can I do? I can do for a summer job I could go along as an instructor. 'Cause it looked like when I was kid there, it looked like the instructors had even more of a blast than the kids did. So I applied for a job as a sailing instructor and it turns out sailing instructors are two a penny, everyone wants to be a sailing instructor and it's a very popular job to do.

BH: Hm.

MM: But in the form they'd just asked what else can you do? And I mentioned oh I do judo and it turns out they were setting up this place where there was gonna be judo as well.

BH: Right.

MM: And so I got a job as a judo instructor, I got the job there as a judo instructor. I had a complete blast for the summer. Turns out indeed it is the case the staff have even more fun than the kids do. I had a wonderful time. And, yeah, that was my first job was being a judo instructor at a kids summer holiday.

BH: What's your judo skills like now?

MM: Non-existant. [laughs]

BH: Oh.

MM: I gave it up at that point. That was my swan song for judo.

[gentle piano music]

BH: So as you pushed through high school you obviously were getting decent enough marks. You eventually you've gotta make decision eventually about university. What happens next?

MM: Yep, so and you know it was a kind of fairly pushy school and so they wanted people to be applying to Oxford and Cambridge, so I duly applied to Oxford. Again I was sort of following my nose, I wasn't really, didn't have a particularly huge career ambition in mind. My sister had actually had been to Oxford. She's quite a lot older than me and so she'd been through Oxford and really enjoyed it and so I kind of had her experience and the fact that she'd really enjoyed being there. So I ended up applying to Oxford and at that point there was a separate exam that they had for getting into Oxford and Cambridge beyond the kind of A-levels, the normal exams that you were doing. So I took that exam which I did quite well in. I think I got quite lucky because you ended up… you put down the place you actually… so Oxford has a system of colleges and so you say which college you wanted to go to but also you put down kind of the second, third and fourth choices. And the first choice I put down was a college called St. Catherine's, which I picked just because it doesn't look like an Oxford college. It's this, you know, brutalist modernist 1960s building which just kind of appealed to me 'cause you know I was a contrarian teenager at the time and you know the other stuff was all old and that gets us back to history again and oh don't want anything to do with that.

BH: Yeah.

MM: So I applied there and I remember saying some really stupid things at the interview. They have an interview process and not surprisingly I didn't get a place there but a couple of the other places interviewed as well. One of which was a college called Lady Margaret Hall. And I'd only applied there at all, you know, I was filling out this list of places and I didn't know that much about Oxford Colleges so I asked my sister, and she said, oh apply to Lady Margaret Hall 'cause there's lots of women there.

BH: Right?

MM: So I put Lady Margaret Hall down and for whatever reason, you know, clearly on that occasion said the right things at the interview so I got offered a place there.

BH: Do you have to also give them an idea of what you want to study?

MM: Oh yeah, no you apply for a particular subject.

BH: Yeah.

MM: So I had actually at that point, you know, the A-levels I was taking were pure maths, applied maths, physics and computer science.

BH: Yeah.

MM: And I really was quite enjoying the physics. I enjoyed the maths a lot too, and it was a little bit of a toss up between, you know, applying to do maths and applying to do physics and in the end I applied to do physics.

BH: For any reason or just like, toss of a coin?

MM: Over the maths? Hm. I think it was probably 'cause I liked the application of it. The fact that it is something where, you know, you can solve a problem and then it actually has some real world implications and you can sort of weigh what you find against what you find in the real world to see whether you were right or not. Whereas maths has that rather more kind of abstract flavor to it.

BH: What was the change from school to university like for you? Like how big a step change was it?

MM: Um. I mean in terms of on the academic side of things, it was a big change. I mean, you know, the change in teaching style is enormous and it's something we still face with students today. Right, that you go from a rather well nurtured environment in school where, you know, everything's done in classes and you're taken through things to a system where there are lectures and where you're expected to be much more in charge of your own education. And that was clearly… that was probably even more the case then, that, you know, no one made you go to the lectures. If you didn't go to the lectures, it was your problem and then, you know, then you just fall flat on your face when you came to do the exams at the end of the year. So it was quite a big change from that point of view.

BH: Were you well suited to that?

MM: Only because I did actually go to the lectures. I'm one of these people that as long as there's a structure there I can kind of force myself to do it and then everything's fine. It's like now, you know, these days I exercise pretty regularly and I'm probably fitter than I have been for quite a while but the reason for that is just because I do the same thing everyday. And I get into that kind of routine and you know I hate it when I'm doing but I just because I'm in the routine I keep doing it. It was the same then, I always went to the lectures. I never thought, oh I'll catch up on this later 'cause it wouldn't've worked and so even if I didn't feel like going to the lectures I did actually go along and sort of engaged with all the stuff I was meant to just 'cause that's the kind of way I am, that once I start down go getting into that routine I stick with it.

BH: And once you're at university and studying physics…

MM: Yep?

BH: Did you start finding a niche, did you find a passion then or?

MM: Not for the first couple of years. So the degree program then had very few

choices in it, until you got to the final year, the third year of the degree. And at that point you had to do these things called options, right? So everything was fairly prescribed until you reached that final year. And we got to the final year and you have to pick these options and again I didn't have any particular kind of huge leanings one way. I still wasn't that into astronomy at that point. You know, I was sort of vaguely interested in it but it wasn't a huge part of my life. And so we get to these options and most of them are things like Advanced Nuclear Physics and Further Solid State Physics where we've already done a whole load of stuff already and it's kind of more advanced material on it. There were just two things we hadn't done at all before which were geophysics and astronomy and we had to pick two options and I figured well if I pick the two we haven't done anything at all on before they'll have to start with the easy stuff. [chuckles] So they're gonna be easier options. So I duly picked the astronomy and the geophysics options. And sure enough they did start with the easy stuff and that was great 'cause it meant that you kinda got an introduction to a whole new kind of subject and it wasn't that challenging at least when you started. But I also got really into the astronomy side of it. I mean I enjoyed the geophysics too but the astronomy really kind of bit me at that point.

BH: Do you remember what it was about astronomy that bit you?

MM: I think it, again, this is weird 'cause this kind of goes back to my father again, right? I actually found that I liked the archaeological aspect of it. The fact that you don't have complete control over things. You have to take what you're given and try and figure out what's going on.

BH: You're picking over the ruins.

MM: You are and you're trying to reconstruct on the basis of this sort of fragmentary information that you get what it all means. And so it really is in that sense very like archaeology. It's, you know, taking those fragmentary bits and pieces and trying to put it together into a coherent story that explains things and then say okay if I'm right then I also ought to see this and so then you can go and do that experiment. So I really liked that kind of almost sort of criminal investigation side of it that you're actually trying to kind of put things back together again on the basis of the information that you've got.

BH: So as you complete through this… the options, astronomy sounds like finally astronomy bitten you, what happens when you come to the end of your degree?

MM: So I'm getting to the end of the degree and I said well what am I gonna do next? I did actually apply and got offered a job. I applied to ICI, big chemical company.

BH: You hate chemistry!

MM: I know, isn't it bizarre?

BH: [laughs]

MM: I applied for this job as a control engineer. So they're the people who stop chemical plants from blowing up, basically they put the safety processes in place. And I went through this quite lengthy process. ICI had this kind of recruitment process. It was an amazingly complicated process. The last stage of which involved them taking their kind of short list candidates to a country house hotel somewhere in the middle of nowhere and doing all sorts of weird things like we sat down to dinner the first evening and the first dish that was presented was shellfish, you know, with all the tools to get the shellfish out of the shells and in retrospect it was clear that this wasn't just dinner, right? This was actually part of the assessment. Who's gonna be the first person who actually tries to figure out how to do this.

BH: Right. I hate that stuff. [laughs]

MM: I know. So do I. Anyway, so we went through all that and they did offer me a job.

BH: You obviously were good with the shellfish.

MM: I clearly didn't completely embarrass myself with the shellfish.

BH: Yeah.

MM: And dealt with all the bits and pieces that they threw at us. It was… you know, 'cause again it was this problem solving stuff. I really quite enjoyed doing. So they offered me a job. But at the same time I was sort of thinking, well you know, I'd actually like to see a bit of the world as well. And again I don't quite know how the though first occurred to me but I realized, you know, that I could go on and actually study for a PhD and I didn't have to do it in the UK. And at the time that was pretty unusual, right? Most people didn't travel overseas to do, you know, for education, and you know, between undergraduate and post-graduate studies. But I did sort of hit on this idea that it would be great to go to the US and do a PhD in the US. I must've had quite a lot of commitment to it, 'cause it's quite hard work because the world really wasn't set up for, you know, British people going to the US to do PhDs. I mean some people did it but it wasn't an easy thing to do. And so you had to this thing called the Graduate Record Exam, which was an exam that would get you into a PhD program in America which was completely different from any exam I'd done before 'cause it was kind of this multiple choice thing which is not something that you do much in the UK education. And you had to apply to all these places and fill in all these forms and put all these applications. And I applied to about four places in the US and got offered places. So I, you know, in the end decided and I still had this job offer from ICI so I was weighing these two things up against each other. In the end I decided I just wanted to have a bit of fun for a few years and see a bit of the world and study a bit more astronomy.

BH: And where did you go to do that?

MM: So I went to Harvard.

BH: And presumably obviously you had to pass this exam but you also presumably had to find a PhD supervisor who liked the cut of your jib and had a topic for you. Who was that and where did you go and what did you specialize in?

MM: So in the US… the US system's a bit different from the UK system. US undergraduates do a broader education. They sort of do a major in Astronomy typically if they're gonna go on to do a PhD. They've done a whole bunch of

other stuff as well, which means they haven't done stuff to quite the same depth, you know, in the UK system you've done this very narrow thing to a greater depth. And so in the UK system you can kinda go straight from and undergraduate degree into do research, essentially, 'cause you know the physics that you need to know, or the astronomy you need to know. In the US system you don't, so they actually use like the first year, year and a half of their post-graduate program doing coursework, and so during that time you don't need a supervisor for your PhD and you kind of spend that time chatting to people, figuring out what you want to do, figuring out who you might want to work for. So I spent that first year kinda year and a bit essentially that, of chatting to people.

BH: And you wouldn't… the coursework would've been pretty easy for you I imagine because you were a bit more specialized than your colleagues?

MM: In principal, yeah. In practice, so the bit that I missed out of the story is that between being and undergraduate and a starting my PhD I was actually ill for a year. So I'd actually kind of been out of the system for a year.

BH: A year? What were you ill with?

MM: It's still… it's an interesting question.

BH: Okay, right.

MM: In that I was basically nauseous for a year. I just felt completely sick.

BH: Oh alright.

MM: It's something that's actually stayed with me ever since. To a greater or lesser extent, you know, there are sometimes where a year goes by and I feel fine and then suddenly it comes back again. And I've poked and prodded by so many doctors about this. To be honest at this point I think it's probably a mental health thing. I think it's probably my brain creating this problem from time to time. In that the thing that fixed it the first time is again, you know, that year when I was being I was being poked and prodded by lots of doctors. None of

them found anything much wrong in the end they put me on anti-depressants and that's what turned it around in the end. So I suspect it's probably a mental health issue.

BH: How did having a year out put you behind the curve when you finally went over to the US then?

MM: It wasn't so bad in the sense that because they did start from this slightly lower level it meant that was kind of probably the right level for me at that point so I kind of matched back into it reasonably well. I actually was still ill when I went, so the other thing that sort of disrupted my first year as a PhD student was I spent bits of it in hospital again being prodded by doctors.

BH: That doesn't sound fun.

MM: No. And the way, you know, if you're feeling sick they do all sorts of very unpleasant things to you to try and find out what might be making you feel sick so, yes, I don't recommend it if you can avoid it. [laughs]

BH: Okay, I'll try. So after this early stage…

MM: Yep.

BH: …of the PhD, you eventually are specializing. What do you specialize in?

MM: Typically finding a PhD supervisor and finding the right match can be quite a tricky thing to do and sometimes you know it's hard to find somebody who actually wants to supervise a PhD student. The nice thing is I was at this place called the center for astrophysics. So Harvard houses this thing called the Harvard Smithsonian Center for Astrophysics. Which is both Harvard run and the Smithsonian Institution, so it's actually, you know, a very big organization. At the time I was there there were 250 potential supervisors. There were 250 people there with PhDs who could supervise a PhD. Now it's huge, it's like well up into the thousands of people there. It's this enormous place. But even then it was a very big place, which meant that actually you're kind of spoiled for choice. And because, you know, Harvard takes, you know, four or five PhD students a

year and there's 250 people there who might want a PhD student, it's not that hard to find a supervisor

BH: Are you picking a supervisor based on the person, or based on the the topic?

MM: Bit of both really. And it's kind of a fairly common thing. It's important when you're doing a PhD to pick not only a topic that you're interested in but actually somebody you get on with because you're gonna be working with them quite a lot. And it's really important there isn't some clash of personalities or those kinds of things. So I ended up working for a guy called Steve Kent who I ended up working for, essentially, because he was teaching… so as I said we spent the first year and a bit doing courses and he actually taught one of those courses and I just really liked his style when he was teaching and I kinda liked the stuff that he was teaching.

BH: Which was what?

MM: So he was teaching galaxy dynamics, so the motions of stars in galaxies. And which is essentially what I then went on to do my PhD on.

BH: 'Cause I guess when a lot of people think of astronomy, that superficial level they're thinking of, you know, the planets and moons and stuff, but you're a galaxy man.

MM: I'm definitely a galaxy man. And at that point it really was dynamics. It was the motions of things within galaxies. I was very interested in how the stars, you know, how they stick together, how the structure is arranged. And again coming back to this archaeology thing, how that arrangement tells you… what it tells you about how the thing got put together in the first place.

BH: What else could you study to do with galaxies besides that?

MM: To study the motions of stars in galaxies you end up taking a lot of spectra because you actually want to measure the Doppler shifts in the lines and things to see whether the stars are moving towards you or away from you or in some complicated fashion. But there are lots of things you could do, you could be

studying, you know just taking images of galaxies, you could be looking for things which might be varying with time like supernova going off in galaxies to learn about their stellar populations. What the kind of stars they're made up from. So lots of different ways of trying to tackle, you know, why galaxies look the way they do.

[Gentle music box interlude]

BH: Just a very quick break to thank our episode sponsor Jane Street, and they're a very appropriate supporter indeed. Jane Street is a trading firm that leans really heavily into research and the curiosity side of things. Now they're not here today to sell you anything, don't touch your credit card, don't worry about promo codes. Rather, Jane Street is well aware that the sort of people who listen to this podcast are the exact people they'd love to see working on their teams across the world. Puzzle solvers, mathematical minds, coders, computery types. With offices in the likes of New York, London, and Hong Kong, Jane Street is a great place to work and they really make sure their people are well looked after. To find out more about all this go to janestreet.com and click on the section that says Join Jane Street. You'll see a list of what's available from full-time jobs, internships and a range of great programs and events. They're running great stuff all the time. You'll also find on the site more about just how well they look after their people. All the great workspaces, the perks, that kind of stuff. So who knows, maybe you're at the start of your career, maybe you're at a crossroads, wherever you're at go to janestreet.com, check out Join Jane Street. And now, back to our interview with Mike.

[orchestral string interlude]

BH: I'm gonna pause for a second and put my Numberphile hat on a bit more firmly. How important was and is mathematics at this point? How good do you have to be at mathematics to be an astronomer at the Harvard Smithsonian Center for Astrophysics, or anywhere else for that matter?

MM: It varies. I mean, you know, there's a whole spectrum, right? You need a certain level of mathematics, that's kind of unavoidable. But they're people who really, you know, study the equations which dictate, in my case for example the

motions of stars within galaxies and prove theorems about them and do all those things that mathematicians do. So it's kind of mathematical physics. And at the other end of the spectrum there are people who largely go out and observe galaxies and the interpretation bit is kind of the bit on the end having made their observations which probably has a little bit of maths in it.

BH: That'd be more basic?

MM: Much more basic and even taking maths that somebody else had already done and showing whether it's right or not, so actually no that much maths involved themselves.

BH: Is it common that a less mathematical astronomer teams up with a very mathematical one and they tackle the problem in the two ways or?

MM: Sometimes, although it's sometimes you reach this situation where you're not even speaking the same language as each other. So it sometimes can be quite difficult to get that kind of interface between the theory side and the observation side. But that's obviously the ideal thing is that astronomy is one of those subjects where everyone does a bit of both. So even if you're an observer you do a bit of the theory side, if you're a theorist you probably have to understand the nature… at least understand the nature of the date well enough that to make sure you're not over interpreting what you're doing.

BH: What are some of the mathematical tools that are used that I might be familiar with like, you know, what are some of the disciplines that you dip into?

MM: I mean, so, again it's across the board. There are people who do, you know, computer simulation, so basically that's 'cause, you know, if you simulate in galaxy in a computer, essentially you're solving the equations which dictate the motions of the stars and the gas within that to understand what's going on. So you really are, you know, you're solving a set of differential equations, you're just using a computer to do it. We tend not to think of it in those terms we tend to think of it, you know, in sort of more physical terms of you know, you're following the motions of stars within the galaxy but essentially you're just solving a set of equations when you do that. So there's the numerical side of

things. But there are also, you know, there's the more kind of mathematical side of things of solving, essentially solving equations on a piece of paper. So the guy I ended up working for, Steve Kent, the reason I ended up working for him is in passing in one of his lectures, he was deriving a bunch of results from a set of equations, essentially the equations which dictate the motions of stars within galaxies. And just as a throwaway point, at some point he said and of course so and so can't be done. Right? And, you know, I was a bolshie, what would I've been, twenty, twenty-one year old at the time. And so I went well I'm gonna go and do this, right? And so that night I sat down with a piece of paper and spent most of the night, probably one of the only times I've actually worked on science through the night, well obviously when I'm observing I do but, you know, actually focusing on solving a problem and I got so into it that I spent the entire night solving this problem. Didn't sleep that night. And in the end showed that he was wrong and that actually you can derive this result that he said couldn't be derived.

BH: Good Will Hunting moment, was it?

MM: It really was. And it was, you know, it's probably the most hardcore maths I've ever done in my life. Which involved, you know, it was lots of solving integrals and doing clever tricks about multiple integrals were you reverse the order of integration and also sorts of mathematical games I played that was, you know, really the pinnacle of my knowledge of mathematics. And I say at the end of it I solved it and then I wrote it up to look nice. Back in the day when people hand wrote their equations rather than typing them into computers.

BH: Your best Mike Merrifield handwriting?

MM: Well actually by that point I figured out that if I wrote everything in block capitals, what I wrote was fairly legible. So I wrote this thing out in block capitals, right? But it was mostly maths so that's alright. My maths is fairly legible, 'cause it's just writing individual characters. Anyway so next morning I go into the office with this thing early in the morning. I stick it under his door, then I went back and slept, right? [chuckles] 'cause, you know I was exhausted by that point. And so the next day I dropped by to see him and he read it by then and he said this is really good and, you know, let's write a paper about this, and

do you want and come and do a PhD with me? Which is essentially the way the conversation went.

BH: Yeah?

MM: And so I ended up doing a PhD with this guy and that was one of the… it turned out that wasn't the first paper we ended up publishing together. We did some, you know, some observational work together and I analyzed some of the data that he got as a first paper. But I think it was probably the second paper we ended up writing together.

BH: Nice one. I'll have to look that up sometime. You complete your PhD presumably, 'cause I call you Doctor and Professor, so I hope you did complete.

MM: Yep! I did, yes.

BH: What did you do next?

MM: So the career path for somebody, and at that point I was kind of quite committed to it, I was really enjoying the science.

BH: Was your father still alive?

MM: At that point, yes, he was still alive.

BH: What did he think about you pursuing astronomy?

MM: I think he was probably a little bemused by it, but yeah he was quite proud I think. He and my mum came over for my graduation from Harvard. So that was a big deal, they came to America for the first time and…

BH: Yeah?

MM: And saw me graduating, so yeah, no that was all very nice.

BH: Oh it was, alright. Did you ever make that archaeology-astronomy link with

him? Say I feel like I'm doing what you do but in space.

MM: We did have that conversation a few times I think and then so, this is probably leaping a head a little bit but one of the pinnacles of my mum's life, she was very proud of both me and my dad, right? My dad had a really interesting progression through, you know, his kind of academic path, in he was the son of a station porter who died when he was very young, so he was brought up by his mum.

BH: A train station?

MM: A train station porter.

BH: Hmm.

MM: So he didn't have an academic background at all.

BH: Mhm.

MM: He ended up doing kind of a part-time degree in London, so he was living in Brighton, did a part-time degree in London which is where he met my mum. But kind of so he sort of pulled himself up by his bootstraps from very little education to doing a degree to moving into museums and so on. But he didn't go beyond his undergraduate degree. So he didn't do a PhD but kind of late in his career he got given an honorary doctorate for his contributions to archaeology by the University of London, which was, you know, obviously a very proud moment for everyone, but just after he got it I was home visiting and somebody phoned and asked for Dr. Merrifield and my mum got to say, which one? And you could hear her [chuckles] kind of glowing with pride when she said this, you know.

BH: [laughs] very nice.

MM: So anyway, that was diversion, what were we supposed to be talking about?

BH: Well yeah, you are Dr. Merrifield now.

MM: Oh yes, I'm now Dr. Merrifield, yeah.

BH: Where's the younger Dr. Merrifield?

MM: Yes I'm the other Dr. Merrifield.

BH: Mhm.

MM: So the standard career path is you do a a PhD, if you wanna kind of pursue that academic career path you typically do these things called postdocs which are these relatively short term positions where you work for two or three years at a place and you move on to another one and you kind of build up your research portfolio and hopefully your reputation to a point where you can get a permanent academic post somewhere. And you typically apply to a whole bunch of places 'cause they're all very competitive. I ended up getting offered a job at a place called CITA, which is the Canadian Institute for Theoretical Astrophysics based in Toronto, based at the University of Toronto in Toronto. So I moved from Cambridge, Massachusetts to Toronto in Canada for a couple of years as a postdoc there. And it was quite, they were nice postdocs in the sense that so CITA was set up very much with postdocs in mind, there weren't many faculty. There were a lot of postdocs, and so it was kind of young vibrant environment to be doing it. But it was a little bit scary in the sense that most postdocs you end up going to work for a person to do a particular thing. For CITA they just give you a fellowship and essentially you turn up and they say okay, well there's your desk, there's your computer, do something interesting. [laughs]

BH: Right! [chuckles]

MM: And so you really are for the first time really kind of pushed in pretty much at the deep in to swim. In retrospect I think there probably was kind of people were keeping an eye on how things were going.

BH: Hmm.

MM: And if you were really struggling people would say, here's an interesting thing you might want to work on.

BH: 'Cause that sounds really hard, 'cause obviously in astronomy, a key thing from what I know of astronomy is to try and get observation time on telescopes maybe or so you can get some data to get your teeth into. But I imagine prestigious professors and doctors find it easier to get that time then some lowly postdoc. So you're really like, you must really be in the wilderness looking for help?

MM: There is that danger. I mean, you know even at that point, so the first thing I did when I was there, actually just used some data that even then was twenty years old. It was some old radio data and I just had this idea about a way to analyze that data that no one had done before.

BH: Right.

MM: So even then there was kind of archival data you could get your hands on. Nowadays things are much better in that there are many many archives and lots of these big surveys and things so there are lots, lots of data that everyone can get hold of. But even then so I started doing stuff. I started working with a guy called Konrad Kuijken who was another of the postdocs there. Again, you get these kind of relationships in science sometimes you just kind of bounce things off each other and get kind of more than the, you know, the whole is greater than the sum of the parts. So we worked really well together. So started doing projects together while we were at CITA and continued for many years after that, working together a variety of projects. We're kind of nicely complimentary from that perspective.

BH: So you're time at CITA obviously has beefed up your CV a bit, you've got more papers under your belt.

MM: Yep.

BH: What do you do then?

MM: So at that point I was starting to get a little homesick. I wanted to come back to the UK, and there were a couple of reasons for that, partly my parents were getting older and I thought, you know, I wanted to spend a little bit more time with them. There's also, I've kind glossed over, but there's kind of a love story going on in the background as well.

BH: Right.

MM: In that I met the person who's now my wife when we were undergraduates together.

BH: Right.

MM: So back in Oxford.

BH: So you'd kept that going long distance or?

MM: We kept it going for a while and then we kind of went our separate ways, but then we kind of got back in touch with each other and were just sort of sending each other letters 'cause back in those days you didn't send people email, you sent them letters.

BH: No. [chuckles]

MM: [laughs] And you know so we were kind of, you know, sort of getting back in touch with each other and so I thought it'd be nice to come back to the UK and so I started looking for jobs in the UK and I came across a postdoc position with a guy called Ian McHardy at Southampton University back in the UK. So I applied for that and managed to get that job, so I then came back to the UK.

BH: But you're still in postdoc world.

MM: So I'm still in postdoc world, so this is now my second postdoc.

BH: I've heard of the postdoc trap where you just go from postdoc to postdoc.

MM: Yep, and I was sort of intent on not falling into it in that I had reached a decision, okay, this is it, this is my last postdoc, I'm not doing any more of these. Just because there is this danger you end up in this internal sort of cycle of these short-term positions and, you know, every time you move it gets harder, right? When I moved to the US, my entire life fitted into two suitcases. When I moved back from Canada, I needed, you know, a shipping container to bring back my life from Canada, just 'cause you get more stuff and it's more hassle to move and you just, you know, you wanna settle down and all those things. Plus by that point I was back in a relationship with the person who's now my wife and she had her own career so I couldn't be draggin' her around the world. So there were all sorts of reasons why I was thinking, okay, this is the end of the line for astronomy for me. But one of the routes out of the postdoc trap is to get a longterm fellowship, like a five or a seven year fellowship.

BH: This is where an organization funds your work for a number of years.

MM: Yeah so for example in the UK the two big funders of this are the Research Councils fund these fellowships and the Royal Society fund these fellowships as well. And the reason why they're a route out is because it turns out that if you can get five years of money you can then go to the University you're at and say, okay, and the nice thing about these fellowships is they're portable, you can move them from places. So you can go to your current head of department and say, okay you can have me free for five years but in return I want a permanent job at the end.

BH: Hmm.

MM: And that's a negotiation which works reasonably well, and in fact if your current institution won't do it another institution almost certainly will. So it's these are a pretty good route into a permanent career in science.

BH: Right.

MM: And so I'd applied one year, I got nowhere. I applied to the Royal Society, I got nowhere, didn't even get an interview with them, so I thought okay I'll do one more cycle of this and then it's time to start thinking about, you know, that

career in computing or whatever else it's going to be. So I put in my final application, Royal Society didn't interview me again but the Research Council one, what was then called PPARC, which was the Research Council that funded astronomy, gave me an interview, so I went through the interview process, it was quite quite an astounding interview process because it's clear, so I was… they interview a lot of people for these fellowships. I was there at the end of the second day of interviewing, they'd done two solid days of interviewing, and this is an interview panel and they're sitting kind of slumped in their seats around the table, and there's spilled coffee everywhere and it's clear, you know, these people… it is total carnage. So I went through this thing and it went reasonably well and actually as I was walking out one of the people on the committee whispered to me as I went out, good job. [laughs]

BH: Right.

MM: So I thought, yes!

BH: Ah good.

MM: And so and that worked out and I got offered the fellowship.

BH: So now you've got the big bargaining chip.

MM: So now I got the big bargaining chip which I took to my boss at Southampton and said, you know, so I got one of these fellowships, what're you gonna do about it.

BH: So you're saying you can have me for free for X number of years.

MM: Yeah.

BH: And then…

MM: Yep. So I, yep, I played my card and they duly made the offer and said, yeah, alright we'll do that, you can, you know, for five years, and there's a quid pro quo, right? They have you for five years, you did a little bit of teaching

during those five years, which they get for free, but then at the end of it they kind of offer you a permanent position at the end.

BH: Right.

MM: So that was sort of me finally set, and you know, as with all these things it's a complete chain of chance that gets you to that point, right? There's the way to end up being the panel on the day you happen to apply for the fellowship, the fact that when you're an undergraduate you picked the subject that you thought was gonna be easy 'cause you hadn't done it before. This whole kind of chain of chance gets you to that point.

BH: Yeah.

MM: But anyway, so that point yeah, I'm all set at that point.

BH: Okay. Southampton that's the start of your career as a grownup astronomer.

MM: Yep.

BH: You're not in Southampton anymore 'cause we're sitting in Nottingham. [chuckles]

MM: Yep! So there's one more move.

BH: Yep.

MM: So I've got this five year fellowship, I'm coming towards the end of the five year fellowship, so I'm still a postdoc. I'm still on this five year fellowship. And again we're back with chance again. I happen to see an advert, it was in a newspaper, for a new professor of astronomy at the University of Nottingham. 'Cause there's no astronomy at Nottingham at the time and they'd been thinking about what, you know, what areas they might want to expand into, what new things they might like to do. Astronomy's very popular with physics departments, firstly 'cause it's very attractive to undergraduates, 'cause undergraduates like astronomy and secondly 'cause it's cheap. Because we don't

need labs and stuff. We do use very expensive pieces of kit but they're all these national and international facilities, not something that the university has to pay for. So at the time most physics departments were kind of expanding into astronomy and Nottingham was one of the later places to do it. So, you know, they put this advert saying they wanted to set up this new astronomy group and they needed a professor of astronomy and with, you know, probably two lecturers to go with it to set up this new research group. And so I applied, not 'cause I had any expectation at all of getting it. I was far too junior.

BH: 'Cause this would'v been like, you know, setting it up. You know…

MM: It's setting up.

BH: Yeah, pioneering.

MM: And I'm still a postdoc, I'm not even faculty at that point. I'm still going through this fellowship. So I'm very junior but again, you know, clearly I'm a fairly obnoxious and pushy individual and so I thought, well why not. And really I was doing it not 'cause I expected to get it but more to put Southampton kind of on notice that this is, you know, I'm going somewhere kind of thing.

BH: Hmm.

MM: And, you know, so, support me or else kind of thing. So I put in an application. I was somewhat surprised to be short-listed. I went along to the interview, again the interview wasn't my finest hour. It's funny when you think back on these things, the only thing you ever remember about them are the really stupid things you said. But anyway, clearly I must've said some good things as well as some stupid things.

BH: Yeah.

MM: And they actually ended up appointing two of us. They got to a point where they couldn't decide who to appoint, so it was me and this guy Peter Coles and the Vice Chancellor just kind of snapped his fingers and so okay well clearly they're both good, why don't we have two of them.

BH: Hmm.

MM: And so Peter and I set up the group, and started, you know, we made an argument that basically said well look, you know, you were originally gonna only appoint one professor and two lecturers, since you've appointed two professors clearly you need more lecturers. We also played this game of getting people who had fellowships. 'Cause again you can play this game of well look, we can have this person for free for five years, so let's have two of them. So we ended up growing the group much more rapidly than the university or the physics department expected.

BH: Hmm.

MM: And really turned it into the fairly thrivingy thing it is today.

[gentle music box interlude]

BH: I mean you've done various things. You've been the head of the physics school here and whatnot. You've also done lots of research. I know you've written a textbook that's quite well known. What's kind of like… what would be, I hope you have more left in you of well…

MM: [laughs]

BH: I hope you have more astronomy left in you of course as well, I'm sure you do, but like as of now what would be like… what's the thing you're most pleased with that you've accomplished as an astronomer, research wise perhaps.

MM: Probably it was the book.

BH: Hmm.

MM: Just because it was this, you know, it's the biggest monolithic thing I've ever done. So I wrote it with a guy called James Benny. Again this comes down to these chance things. So the book's called Galactic Astronomy. There was an

early edition, an earlier edition of called Galactic Astronomy by Mihalis and Binney, okay, the two authors. And it was clearly very out of date and James Binney said well look we need to update it and Mahiles said well I don't want anything to do with, I've had enough of writing books. So James was looking for a co-author and I wasn't his first choice. But somebody wrote one chapter with him and said, oh, I can't stand anymore of this. [chuckles]

BH: Right. [laughs]

MM: I'm not doing any more of that. So James approached me, and I think the reason he approached me was because this was while I was on that five year fellowship and he was thinking well this is somebody who's got a bit of spare time to do this stuff. Because it's a big commitment and typically, you know, if you're a member of faculty you don't have time 'cause you're doing this teaching. If you're on a short-term postdoc you don't have time because you have to be thinking about the next job you're applying for. You can't make those. So I was in that kind of position of being able to invest the time…

BH: Mhm.

MM: …to write the book. And so James and I wrote this book between us.

BH: And it's kind of a catchall for galactic astronomy obviously.

MM: At the time, so it came out in 1998, so it's horrendously out of date now. Things have moved on a long way. But at the time it was kind of supposed to be the definite view of what we know about galaxies. Kind of slightly from the perspective of the Milky Way and working outwards to other galaxies which probably isn't the way you'd do the book if you were doing it now but yeah, it's sort of this overview of what we know about galaxies. And it's sort of a undergraduate, postgraduate level kind of textbook really.

BH: This is obviously synthesizing a lot of research done by the whole astronomical community. What about you yourself research wise? Has there been sort of a most cited paper or sort of… there's no like, you know, Merrifield Phenomena out there or anything but is there like a… is there a thing you're

associated with or you associate yourself with at least?

MM: Um… you know I'm happy to say I don't know what my most cited paper is, which is sort of good news, right? 'Cause it means I'm not the kind of person who sits there looking up their own citations all the time. So I don't actually know what my most cited work is. What am I happiest about?

BH: Has there ever been a moment where you've realized something or just felt like you've sort of discovered something or like you thought, oh I think I've figured that out and then you know, turns out you were right.

MM: I mean probably the biggest example of that was that thing that got me my PhD supervisor in the first place, right? That was the classic example of that. And that interestingly that's been a very slow burn. In the sense that it was very much kind of I showed that in theory something is possible, right? And the interesting thing is that since then the world's kind of caught up with that in the sense that people are now doing the stuff that I said that was possible in theory. That is really rather satisfying. That having, you know, derived this result, which at the time was this very abstract kind of thing. People are actually now using it to get real results in astronomy and learn a bit about the way the universe works.

BH: Is there an executive summary of what it involves, what it's about? We've talked about it so much now I have to ask.

MM: [chuckles] Okay, so, it's to do with the fact that if you could measure the speed at which a whole bunch of stars are moving in a galaxy or a cluster of stars or whatever it is. You'll find they have a distribution of speeds, right? They don't all move at the same speeds and in particular if they're all moving in fairly random directions then you find that typically the distribution looks pretty much like a Gaussian.

BH: Some of them are going really fast, some of them are really slow, most of them are going…

MM: Well actually the most, as with a Gaussian the most common thing is zero. So actually the motion along the line, if you're measuring for example the motion

along the line of sight the most common answer you'll get is zero. And then there's kind of a tail of things out to higher and higher velocities. So some of them are moving towards you, some of them are moving away from you and you end up this sort of tail. But this is characteristic distribution you get in all over the place in physics, this thing called a normal curve or a Gaussian curve. And more or less the motions of stars follow a Gaussian curve, their motion is towards you or away from you.

BH: Yeah.

MM: But not quite. And so what I was looking at was the departures from that Gaussian shape, and what that tells you about the orbits that the stars are following. And it turns out you can learn a lot from the departures from that Gaussian shape. It's very hard to measure because essentially you're trying to measure well, how much stuff is there in the tails of the distribution, way out here, and the answer is is it one star or two stars, right? And so it's really hard to measure.

BH: Hmm.

MM: And as soon as you got any noise at all it gets even harder to measure. But that essentially I showed that there is a quite a kind of fundamental piece of information that you can learn from the departures from the Gaussian shape. And in particular there's this sort of fundamental result in physics called the Virial Theorem which relates sort of the width of that distribution to the mass of the galaxy that it's sat in. So a more massive galaxy, the characteristic speed, the characteristic random speed gets higher and higher. So that's this thing called the Virial Theorem. I showed that there were kind of analogs of the Virial Theorem associated not just with the width of the distribution but actually the detailed shape of the distribution and how much it departs from that Gaussian shape. And as I say…

BH: We'll put a link in the show notes to your paper.

MM: Yeah, okay.

BH: [laughs]

MM: And it was horrendously hard to measure. As I say it was really sort of slightly a theoretical result and it sort of due to with showing actually you can use that shape information to learn more about the distribution of the orbits and actually also to learn about the mass of the galaxy in this new independent way 'cause the Verial Theorem is a way of measuring the mass of the galaxy, I showed actually there's another way to measure the mass of the galaxy in this rather subtler way. At the time there was nowhere near enough data to actually do this. But now there is and actually people are using this method to measure the mass of galaxies and measure the distribution of mass within galaxies, learn about dark matter, all that kind of stuff. It's sort of this very kind of theoretical result that I came up is now actually being use to learn something about the real properties of galaxies.

BH: Mike when I first started working with astronomers like you, I sort of created this picture in my head that astronomers decide they want to discover something or they have theory they wanna then prove is the case, they apply for time on these telescopes whether it's the ones here on Earth or maybe the ones up in the space. They get approved, yes you can have two hours of this telescope on this night. You point it where you wanna point it, you find out if you're right or wrong or you discover something new. It now seems to me a lot more of the time astronomers are actually using preexisting observations. Huge reams of data, surveys, that have been done in the past and they're just picking over the wreckage in a new way or looking for something new in that existing data that no one has seen before. Is it more that way, is it fifty-fifty, is more one or the other. How does it work being an astronomer, a research astronomer?

MM: I mean it sort of evolved with time, right? In that when my career started the first thing you described of this model of having an idea, applying for time on a telescope, making your observations, analyzing the observations, interpreting them, writing a paper. That really was the way it worked for the vast majority of astronomers. Now I would say probably the majority of the astronomers are in the other model where there are these big surveys going on. They're part of large teams and they're all trying to come up with clever new things with these large datasets. Astronomy's gone from being, you know, when

I started we were incredibly data starved, right? There wasn't that much data and you would really fight for every photon and pick over everything and really analyze your particular little bit of data. Now we're very data rich, there are these massive surveys going on. There are so many ways you could mine that data that people are kind of always coming up with new things to do with the existing data.

BH: Then it feels like more and more of a role for mathematics, a lot of number crunching.

MM: There is a lot of number crunching. Probably the biggest change, and the biggest thing that's revolutionizing the way this data is being mined is machine learning. Right, that actually people are able to analyze huge amounts of data in ways that they haven't even thought of themselves because the machine learning comes up with the ideas for them. So actually that's probably the biggest change in terms of the way we're analyzing the data is that a lot more of it is more automated and actually letting the machines take over to an extent as well.

BH: How do you feel about that? You strike me as more of an old school kind of guy.

MM: [laughs] I'm very old school.

BH: Yeah? [laughs]

MM: I somewhat facetiously, and you know 'cause the other thing that goes with this is astronomy's being done in bigger and bigger groups. You know, when I started out you'd do your papers on your own or you know, like I got together in this collaboration with Konrad Kuijken. We wrote papers together. We'd just sort of sit down and have ideas together. I love that. I love that kind of being able to see working in a small group, working something through from all the way from that initial idea sitting in the bar with someone chatting, writing things on the back of a beer mat all the way through to proposing to observe, going out, making the observation yourself, analyzing the data, writing the paper. I loved that whole process. If you're doing stuff in these big collaborations you don't do that anymore so much, because you're just a cog in a machine and you're

probably responsible for some part of the data reduction pipeline and so on and you know as I somewhat facetiously said in the past if I had wanted to do that kind of science I'd have become a particle physicist.

BH: [laughs]

MM: Because that's very much the model for experimental particle physics where they do these huge monolithic experiments, which by their vary nature involve huge numbers of people all of whom specialize in some little bit of the experiment and I don't find that interesting. I really don't, I love this being able to see everything through from that beginning to end and seeing the whole project and managing the whole project and doing the whole thing yourself.

BH: But is that sign of the maturity of the science, like does it get to a point where you know too much for one person to be able to do that anymore. You know, that's the problem with particle physics, isn't it like?

MM: And it's the same thing. And actually it's because… and it's cost too, right, is the other thing. As with particle physics, you know, astronomy is getting more and more expensive, you know, the telescopes we're building, so we're building this extremely large telescope now, which I'm involved a bit with, which is, you know, it costs about a billion pounds, billion euros, billion dollars, it's a billion for pretty much whatever currency you want, or plus. You know, it's more than that. And so these kind of facilities you can only afford to have one or two in the world, and it's the same with the particle physicists, you know, their cutting edge, you know, colliders are… there's only one, at any given time. And that means, if, you know, you have to work unless if you're only gonna have one astronomer or one particle physicist, you end up having to work in these large collaborations and they're big projects which do need lots of people. So the nature of the subject kind of changes as the technology changes. Kind out of necessity.

BH: It feels like astronomy's in a good place but it always feels like astronomy's in a good place 'cause there's always cool new pictures on the news, isn't there? Black holes and the stuff we're getting from JWST and things like that. Is astronomy in a good place at the moment?

MM: I think so. You know, we do have this great thing that there's always stuff that's just beyond what we can do with the current technology, and again, it's seems largely technology driven, that you know back in when, the early 1990s we didn't know anything about planets going 'round other stars, right? And now, not only have we detected them and been able to show they're there we can actually even take pictures of them, you can see a planet going 'round another star. But we're not quite yet and we're just getting to the point now of actually being able to analyze the atmospheres of those planets, to understand more about what's going on in those planets. So some of the JWST data, the early JWST data was actually looking at the atmosphere of an exoplanet and it's one of the big things we'll be able to do with the EELT. But eventually, you know, you reach a point where not only can you study the atmospheres but you can actually look for these things called biomarkers, you can look for life on these planets. So all the time because the technology's pushing forward, the things you can do is you can take the things that you know about and learn more about them, and of course while you're doing it you discover a whole bunch of other things that you didn't know anything about and that then gives you the raw material for the next generation of stuff of oh we discover this whole new class of things while we were trying to find something else and now what are we gonna learn about those.

BH: Hmm.

MM: So yeah, there's no end in sight, I think.

BH: Obviously there's been a lot of interesting things happening in traditional proper astronomy like these telescopes and new discoveries. Also, there's been this real renaissance for human exploration, partly 'cause of all the private stuff that's being done but also NASA and whatnot are getting their act together again. I never think of that actually as astronomy, but is that something astronomy rides on the coattails of as well and is able to sort of keep itself relevant?

MM: I think so because in the public perception the two are very closely connected together.

BH: Hmm.

MM: And you're quite right at a practical level there's very little interaction planetary exploration and astronomy. I mean there are, you know, there are planetary scientists who use telescopes to study planets and are very happy when a space probe goes and gets them a closer up view, right? But for people like me who study galaxies, you know, you don't get any closer to another galaxy by sending a space probe out. So there isn't that much connection between the two but it clearly excites the public and you know when we go to Mars there's gonna be a massive thing again about, you know, interest in science and astronomy. And science in general benefits when these things happen as well.

BH: As a galactic astronomer, when we start going to Mars, is that good for you or bad for you because I can see how it would be good for you because space is becoming more relevant and more money's coming and people are pro-space, but on the other hand that pot of money that is going into spacey stuff might start going more into Mars stuff and less into where you want it to go. [chuckles]

MM: There is that but it's not a zero-sum game, right? The more interest there is in science the more money goes into science…

BH: The rising tide lifts all the boats.

MM. …for science. It does. It really does and it's not so, no there isn't that kind of level of competition I don't think and I'll be as excited as anybody else when somebody first lands on Mars.

BH: I know you have lots of opinions on everything Mike. [chuckles]

MM: [laughs]

BH: But one thing I do wanna mine your opinions on a little bit is I'm imagining some of the people who've listened this far [chuckles] will be quite interested in career path and progression, some of them may want to be an astronomer. You

obviously have a lot to do with admissions and see students coming in all the time into university, what have you got to say about that, have you got advice or just observations about the sort of people who are coming through to… that want to be astronomers that wanna do what you do. Are they the same people they've always been, is there something they should bear in mind? I'm just curious to hear what you think about that.

MM: When I talk to our new undergraduates when they come in or even when I'm talking to prospective undergraduates and talking about what they might want to do as a career wise, the most common answer that they want to be, you know, they want to go into academia, they want to do research. They want to do science as their career. And I think, you know, the advice I would give at that point is by all means go for it but, you know, bear in mind quite what a chance you think it is. You know, my whole career as we've been talking about is based on random things happening and you end up kind of doing these random walk through your life and the chances are, you know, if you start in one place and want to get to another place and you're doing a random walk the chances of you getting there are pretty low, so I think the important thing is just to kind of keep your options open as much as you can and not fixate and not think somehow your personally a failure if you don't get to where you wanted to get to because so many things are outside your control it's ridiculous to kind of beat yourself up if you just don't get where you originally planned to go.

BH: Do you ever get people coming in here saying I wanna be an astronomer, I wanna study astronomy and you look at them and think, I don't think you should. Like, like obviously you would never say that to them and you know everyone can do what they want but you hear their motivations or their strengths and that and you think I don't think you actually wanna be an astronomer.

MM: Except, you know, if I look at my own motivations along the line is they haven't actually been filled with glory in large part, or you know the fact that I got into astronomy at all 'cause I was lazy as an undergraduate and wanted an easy option. You know, there are many reasons people end up where they are and it's not really not my place to say actually you know what, your motivations bad here. I don't think that's the case. The other really important thing to say is

and again, this comes back to this kind of odds against success things, is when I'm talking to people who are applying for PhDs or even you know going through a PhD and thinking about their career… future career. You know, these are people who are studying a quantitive subject so I get them to do the quantitive analysis of saying, look, me personally through my career I probably supervise…before I retire, what 20 or 30 PhD students, something like that, just 'cause that's I take on a PhD student every couple of years and my career's 40 years maybe that's 20 PhD students. In a statistical sense when I die, one of them gets my job, because actually if it's more than one we end up with an exponentiating number of astronomers and the world really couldn't deal with that, right? So that's the odds, right? That actually the odds are 20 to 1, or whatever it is, that it really is that hard a career path to follow just because that's the way the numbers work out. And as long as you go into it with kind of your eyes open and saying okay this is what I really want to do but I recognize it's a long shot and therefore, you know, it's sensible to be thinking about what's plan B, that's fine, but I do worry when people say, I really want to be an astronomer and I'm going to be an astronomer and nothing's going to stop me, because actually almost certainly something will, just because as I say so much of it is not actually in your control.

BH: What are some of those plan Bs? What are some of the good astronomy students you've had here gone on to do?

MM: A huge array of stuff. So one of my recent PhD students has gone on to, she's working for one of the finance companies in Nottingham now, so big finance houses looking again analyzing data and you know looking for patterns in it, very much the skills that she acquired as part of her PhD, she's now applying to analyzing finance. Another PhD student, a recent graduate, he's now working for Ordinance Survey, actually down in Southampton, so going back to my roots.

BH: Oh I'd love to work for Ordinance Survey.

MM: It's such a cool job. It really is.

BH: Yeah.

MM: ‘Cause the thing that he turned out to be really good at in his PhD was coming up with clever ways of visualizing data. And of course he’s taken that skill and using it enormously well now, and doing all sorts of stuff of, you know, he was modeling Covid spread in the pandemic, he’s looking at water distribution now. Obviously we have a bit of a water crisis at the moment in the UK. So looking at how you move water around and where the extra supply is, where the deficiencies are. All sorts of cool stuff like that that he’s involved in.

BH: Ordinance Survey sort of the mapping agency of the UK for those who don’t know.

MM: Yeah, yeah yeah yeah.

BH: Alright.

MM: Yeah they make maps, yes.

BH: Do you ever wish you were in a submarine? Did they change that submarine requirement?

MM: They do now. I think, yeah…

BH: Yeah?

MM: You don’t… you only need 20/20 corrected vision now, not 20/20 uncorrected.

BH: So you could do it.

MM: Yeah, I’m a bit old to be a submariner at this point.

BH: Do you ever wish you’d done that?

MM: Um… no not really. [laughs]

BH: No?

MM: No, you know, so I have actually… so my wife has worked in various areas of administration, including local government and so when she was… when we were living in Southampton she was quite senior in the city council in Southampton which meant we got invited to various receptions and things. I got to go along as And Spouse, and one of the receptions was the nuclear submarine HMS Southampton came to visit Southampton and so we got to go and nose around a nuclear submarine and chat to the submariners and stuff.

BH: Nice.

MM: And I came away from that thinking, actually you know what, I'm glad I didn't end up in one of these. [laughs]

BH: Too much like sardines, or?

MM: It really is pretty small.

BH: Hmm.

MM: I hadn't realized quite, you know… and so one these things called an attack submarine so it's not one of these big tactical submarines, it's quite a small submarine. And yeah, it really is very small.

BH: Any other career you would have liked to have done? Do you ever look and thing, oh that's a cool job.

MM: Well it turns out I'm quite a good goalkeeper, so actually, you know, maybe I should've been a footballer.

BH: Footballer?

MM: [laughs]

BH: Goalkeeper? Who would you have liked to have played for?

MM: Oh, well again it's one of these funny things and it's again it's sort of people have… it's about people's expectations of you, right? When I was at school I was kind of, you know, the nerdy kid, and so no one would ever really pick me for the football team, just 'cause it's just not what you do. But actually when I moved to Nottingham somebody was setting up a five a side team and they couldn't find a goalkeeper and I said, well that's alright I'll give it a go. So it turns out you only need two skills to be a goalkeeper. One is you need very fast reactions and the other is you need absolutely no sense of self preservation.

BH: Yeah. [laughs]

MM: And it turns out I had those things.

BH: [laughs]

MM: And so I made a really good five a side goal keeper and, you know, was the reason, pretty much why our team really started succeeding because I could keep most of the balls out of the net. So yeah I could've had a career as a goalkeeper.

BH: Alright.

MM: [laughs]

BH: Nice. Let me ask my cat's in the cradle question, it felt like you pushed back against archaeology a bit 'cause that was dad's thing. You're now a dad.

MM: Yep.

BH: Does your young one have an interest in astronomy.

MM: None at all. [laughs] And in fact so he's just finished his first year at university, he's studying history. So he's gone back the other way. [laughs]

BH: [laughs] It's oscillating.

MM: [laughs] Yep.

BH: Does he have an interest in your father's work?

MM: Not at the moment, I mean only in you know, the abstract. You know, my dad died before he was born so he never got to know him. So he only knows him kind of in the abstract, so I think he's you know, he's sort of a little bit interested in the fact that his granddad was an archaeologist but again he's more interest in football in history at this point.

BH: Your dad wrote a really good book, too, thought didn't he?

MM: He wrote a bunch of books actually, yeah, he wrote I mentioned there was this kind of paradigm shift of going from archaeology being all about rational explanations to all about ritual explanations, so he wrote this book called the Archaeology of Ritual and Magic which is kind of the original kind of founding textbook of that whole discipline.

BH: Alright well we'll link to your book and your dad's book…

[gentle outro music fads in]

MM: Cool.

BH: In the description.

[music fades up and down]

BH: Well that's all for today, our thanks again to Jane Street and a reminder their site is janestreet.com. Also do take a look at the notes for this episode, I'll include links to Sixty Symbols, the physics channel I mentioned earlier, Mike features really heavily there. And Deep Sky videos which has been a real labor of love for both Mike and myself, with the help of several other astronomers we've made a 110 videos about each and every of the so called Messier Objects. This is a catalog of galaxies and other phenomena which has a very special place in astronomy. Do check them out. I'm Brady Haran, you've been listening to the Numberphile

podcast and we'll be back again soon with another episode.

[Music fades up and out].