Marcus du Sautoy: Interview

by Manjil Saikia - Monday, February 29, 2016

http://gonitsora.com/interview-marcus-du-sautoy/

Professor Marcus du Sautoy is the Simonyi Professor for the Public Understanding of Science and a Professor of Mathematics at the University of Oxford. Formerly a Fellow of All Souls College, and Wadham College, he is now a Fellow of New College. From 2012-13 he was President of the Mathematical Association, UK. He was previously an EPSRC Senior Media Fellow and a Royal Society University Research Fellow.

*His academic work concerns mainly group theory and number theory. In October 2008, he was appointed to the Simonyi Professorship for the Public Understanding of Science, succeeding the inaugural holder Richard Dawkins. Prof. du Sautoy is well known for being an excellent spokesperson of mathematics, mainly due to his three books **'Music of the Primes'**, **'Finding Moonshine'** and '**The Number Mysteries'**. His new book '**What We Cannot Know'** explores whether there are any questions in science that will forever remain beyond knowledge.*

He was awarded the Berwick Prize in 2001 by the London Mathematical Society for the publication of outstanding mathematical research. In 2009 he won the Michael Faraday Prize from the Royal Society of London for "excellence in communicating science to UK audiences". He was appointed Officer of the Order of the British Empire (OBE) in the 2010 New Year Honours "for services to Science". In 2012 he became a fellow of the American Mathematical Society.

In the end of May, 2015, he had a conversation with our Managing Editor, Manjil Saikia and answered a few questions. We reproduce the conversation verbatim below, only making minor changes due to speech pauses and punctuation. Valuable assistance was given by Bishal Deb, our Editor towards the questions below and typesetting the entire conversation.

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Manjil Saikia (MS): At the very outset, we would like to know how did you get interested in mathematics?

Prof. Marcus du Sautoy (MDS): I wasn't somebody who was immediately captured by mathematics. When I was at primary school I wasn't particularly good at my multiplication tables and I found all of it boring at that stage. Some people enjoy doing calculations but that's never been something that I have enjoyed doing. It was really when I was around 12 or 13 that a maths teacher at my school (I just went to a normal comprehensive state school in England), said in the middle of a class, "du Sautoy, I want to see you after the class". I thought I was in trouble. At the end of the lesson he took me around the back of the

maths block and said that he thought I should find out what maths is really about. He explained that the maths that we were doing in the classroom was not real maths, that actually the exciting bit of maths was the big stories. Stories about prime numbers, about different sorts of infinity, higher dimensional geometry, etc.

I didn't understand any of these things at that time but he gave me some books which he thought would open up this world. It was a bit like he gave me a secret key that accessed this secret garden that was somehow walled off from us at school. Bizarre that we weren't all allowed. So I fell in love with maths then.

 Prof. du Sautoy
(Image Courtesy: [Twitter](#))

There was one book in particular called *"The Language of mathematics"* that intrigued me. I was already quite fascinated in languages and different ways of expressing things but I found languages quite frustrating because they had all these irregular verbs, strange spellings and I was really hankering after something which had some logical consistency. When my teacher showed me this language of mathematics I realised here was a language that made perfect sense. That's not to say everything was predictable and boring. It has wonderful surprises, twists and turns. It's not all completely obvious. I realised that this was the language that I wanted to learn. Many people can probably identify one teacher that did something that inspired the choices they made in their lives. Maybe it was just the fact that this teacher took an interest in me. I met up with him some years later for a radio programme on BBC and I asked him why did he pick me out; did he do it with other kids? And he said "No, I only ever did it once, with you." And why did you pick me out? I wasn't amazingly ahead of anyone else. And he said *"Well I just could see that you were responding to abstract thinking and enjoying the kind of idea of this abstract world of thought. And so I knew that mathematics would be delightful for you."* I am very thankful to that teacher for having done that. I think that was the catalyst for everything I've done since.

MS: I have read this part in your book 'Finding Moonshine'. It is a very interesting book.

MDS: That's a good place to check out that story.

MS: Was there anyone else apart from your teacher who motivated you?

MDS: Yes. I think the other lucky break I had was the chance to attend something called the *'Christmas Lectures'.* These are lectures for children done by the Royal Institution for promoting science. They've been going since 1825 when Michael Faraday first started doing them. But despite the fact that they had been going since 1825, it wasn't until 1978 that for the first time they were ever dedicated to mathematics. I was 13 and my dad took me along to one of those lectures and I watched the rest of them on television. They were done by Christopher Zeeman who is a great topologist and was doing really interesting things about René Thom at the time, about catastrophic theory. But as well as being a very influential mathematician he was somebody who was prepared to try and explain these big ideas about mathematics to 13 year olds and 14 year olds. I think I suddenly had a role model.

My teacher was great but here was a really professional mathematician who was telling some of the stories from the frontier. I came away from those lectures thinking that I would like to be like Zeeman

when I grow up. Interestingly I got the chance to give my own Christmas lectures at the Royal Institution in 2006. I was able to pay back Zeeman and the Royal Institution, to say thank you for inspiring me and to hope that my lectures would inspire another generation of mathematicians. I think Zeeman is a great role model because he was somebody who did great mathematics but he was also happy to spend some time trying to communicate mathematics beyond the confines of our academic community. I think that's important for me. Science and maths has always been about discovery and communication. I don't think an idea begins to really come alive until you communicate it to as many people as you can.

MS: As a mathematician you are dedicating yourself not only to research but also popularization of maths. Was there any special reason for doing this?

MDS: I think it comes back to the answer I just gave, that I think as scientists we all spend time communicating our ideas and it's just about how broad you are going to go. Are you going to stick to just trying to communicate to the 20 people in the world who will understand your particular interest of mathematics or do you want to have a go at trying to communicate the ideas more broadly. I suppose I do this as a way of paying back my teacher and Christopher Zeeman and all the people who wrote the books I was fascinated with as a student at school. I think it's our responsibility as this generation to do the same to inspire the next generation. But I think it is more than that because the audience that I try to target is not just children or the next generation of mathematicians. It is also trying to influence society because I think in India much more respect is given to mathematics and mathematicians but in Europe, especially in England, it is almost a badge of honour to say that you are bad at maths.

I wanted to try and convince politicians, employers that actually mathematics is a really powerful language and can give you an edge in this world and that it needs more respect that it was getting. I think it has been getting more respect over the years I have been trying to promote mathematics. I think there has been a kind of sea change in people's attitudes to mathematics. Now there is kind of, what I call, a geek chic, that it's okay to be good at math. After all the best inventions are coming from those that have mathematical tools.

But I think one of the other reasons that I spend time popularizing mathematics is that *I love talking about my subject. I really enjoy explaining why I find it so fun. So whether it's through the television or writing books, radio or doing some weird theatrical mathematical play or something I really enjoy communicating my enthusiasm for the subject.*

MS: Even in India people feel proud to say that they are bad in maths. :)

MDS: Oh really. You spoilt my story now 'cause I always pick you out as a nation proud of doing maths (Gives a hearty laugh).

MS: Have you faced any great difficulty while trying to put forward mathematics in a way that is understood by the layman?

MDS: Well, that's an interesting question because one of the books that inspired me to become a mathematician, one of the books my teacher recommended is *'A Mathematician's Apology'* by G.H. Hardy. And the opening sentence of that is really a warning to anybody who is attempting to popularize mathematics because Hardy writes: *"It is a melancholy experience for a professional mathematician to*

find himself writing about mathematics. The point of being a mathematician is to prove theorems, not to talk about them." So, I think, my generation has lived under a sort of spectre of this message that "yes, if you are a mathematician then you should just be doing maths. You shouldn't be trying to popularise it or communicate it." So I think that, when I first started my attempts to communicate maths beyond just my academic community, I was nervous of what my fellow mathematicians were going to say. It was a risk and I knew that there could be a backlash of fellow mathematicians saying *'well that's not what a real mathematician should do'.* Maybe I did it at just the right time but I found actually that because our community realized that *unless we have spokespeople for our subject it's going to die.* You need people to recognize how important it is in order to inspire the next generation of students. So I got a lot of good feedback, mostly from my fellow mathematicians, saying 'you know it's a really great thing that you are doing this.'

 Image Courtesy: [Univ of Oxford](#)

I think the other challenges were, having to explain really difficult abstract ideas to the public. I took a fairly big challenge which is the [Riemann hypothesis](#) (RH) and in my first book *The Music of the Primes* I tried to explain what it means. I remember my head of department saying you must be crazy trying to communicate such a difficult problem. But I think that's also one of the points of doing this because I think it really helps you to understand your own mathematics if you can try and explain it to somebody else. David Hilbert once said, 'You can only truly say you understand a subject when you can explain it to a man or a woman in the street.' I think that's quite a big challenge for a mathematician to engage in. Okay, so take what I am doing. Can I really explain it? Why I am doing this or why is it important. *I think that I myself got a deeper understanding of my subject through writing my books. It wasn't it just a one way process. I benefited too mathematically, engaging in telling my stories to the public.*

MS: Your book on RH is a great example of popular science book. Is there any plan to introduce some other topic in that manner in the future?

MDS: Yes, well I suppose *Music of the Primes* was the first book. I wrote that book partly in response to the proof of [Fermat's last theorem](#) because I felt this great unsolved problem had been taken from the public's imagination. And people thought that was the last theorem and maybe we'd finished maths. So it was partly to show people that there's something really more important than [Fermat's Last theorem](#).

And then my symmetry book *Finding Moonshine* was very much about my own area of research which overlaps with ideas of zeta function. Then my third book which is *The number mysteries* describes the ideas that I talked about in my Christmas lectures. The lectures talked about some of the big open problems in mathematics. But the book I am working on at the moment is actually a book covering a much broader canvas. In 2008 I took over from Richard Dawkins as the Professor for the Public Understanding of Science in Oxford and this new job has given me an interesting platform from which to look at areas of science just beyond mathematics. So this new book is called *What we cannot know* and it's about limitations of knowledge.

I am interested in questions in science that by their very nature may not have an answer. Is the universe infinite? Well, if it is infinite could we ever know that? How could we ever know that? Will it be something that will always be beyond our ability to know? In mathematics we have an interesting

example of limits of knowledge which is Gödel's incompleteness theorem. This theorem shows quite amazingly that you can prove that there are things within any system for number theory that will be true but can't be proved. But can we prove such a theorem for other bits of science? Can we show that physics or cosmology has provable limits to knowledge? What I am doing is to try to bring my mathematical mind-set to look at different problems across the sciences.

MS: As the professor of public understanding of science, how has your experience been with the way public see science?

MDS: Actually in England there is an exciting appetite for learning about science. We make some great programmes on the BBC about science. I think the BBC is making them not for worthy educational reasons but because the public actually enjoys hearing about scientific stories. So I think there is a very positive vibe towards science at the moment. *But there is also a sort of danger as well which is a kind of anti science backlash. I think this backlash grows out of fear and not understanding.* That's why I think these professorships, there is a couple now, and across the universities of England is very important. *Science is having such an impact on society that people need to understand the science if they are going to be politically engaged and make decisions about out future. What are we going to do about climate change? How are we going to feed the world? What about medical research? The ethics of using stem cells?* Well, you can't answer these questions if you don't understand the science. You need to know what stem cells are even before you begin to argue about it. And I think a lot of this kind of fear about something like genetically modified crops are really a misunderstanding or lack of information. So I think my new job plays a really important role in what is a highly scientific age.

MS: There is something similar going on now with a neutrino project in India, some groups are protesting without knowing about a neutrino.

MDS: That's absolutely bizarre. *I think ignorance breeds fear. And the way to counter that is to try and engage.* But it has to be a dialogue. Scientists need to realize that it is not a one way process and we need to listen to what society wants as well. I think a lot of the problems have occurred because we rather stayed in our scientific silo and it's important to break that down. I think that we all make more progress if we actually talk to people because somebody might have a question we never thought of or a viewpoint which would give us an idea which sets us on a new journey. So I think more dialogue can only be for the good.

MS: There is a great difference in the mathematics that professional mathematicians do and the public perception of mathematics. For example, in physics at least people can see tangible examples of things but in mathematics it is not always possible.

MDS: Yes, I think that's one reason that it took so long for mathematics to be one of the Christmas lectures. The lectures started in 1825. The first time they ever did one on maths was in 1978 and it is this challenge of how do you actually get people to understand something which doesn't have any physical existence maybe. But I think at its heart people love stories. So you have to find the stories which excite people, for example the idea that there are different sorts of infinity. I think people get quite fascinated by that idea, an absolute philosophical idea, well gosh! Does infinity even exist? But now you are saying that you can compare them and say one's bigger than the other? Often what I find is a very powerful way to engage people is to connect some mathematical idea with something which has a more artistic flavour.

For example music is a very highly abstract world with a lot of structure and patterns. Well if I can show you that quite a lot of music has mathematical patterns and structures in it then people begin to say "well, I love music and I understand the patterns there and you are saying that the sort of thing that you are doing as a mathematician are similar to that?" So, I think, that for me that is a way to try and bridge those gaps because people are happy in some abstract worlds in some mediums like music or art so why not mathematics. It's about finding those connections.

MS: How to bridge this gap? Your [TED talk on symmetry](#) is a good way of showing abstract mathematical concepts to the people. What inspired you to study symmetry?

MDS: The symmetry book is an interesting one. The mathematics of symmetry is really a movement from something which is very tangible and visual to something very abstract. But this abstraction allows me then to tap into symmetries in high dimensions or symmetries that don't really have any sort of physical reality. And I suppose for me I got drawn to symmetry quite early on because I love this idea of creating a language that helps you to understand something quite slippery. Galois' creation of the language of group theory changes symmetry into something much more linguistic. I found that absolutely fascinating and I think the really exciting revelations in mathematics are when you see these changes of language which allow you to suddenly articulate and go so much further.

So for example Descartes found a way to turn geometry turning into coordinates and numbers. But it was using this dictionary that helped Riemann to realize you don't have to stick to three coordinates; you can do four, five, six, n-dimensional. That gives you the ability to suddenly start describing shapes in high dimensions. So you can never see a sphere in six dimensions but it's quite easy to write it down and start playing with it and that's really magical. I think that goes back to the fact that I really loved languages. Group theory is an extraordinary language for actually exploring the geometric world around you.

MS: What are your current research interests? What kind of problems do you study?

MDS: I am still interested in one of the questions I was talking about in *'Finding Moonshine'*. I used to be very much interested in infinite groups but now I am quite intrigued by seeing how many groups there are with a finite number of symmetries. For example how many groups are there that have order a power of p. In *Finding Moonshine* I describe my discovery of a new group of symmetries that has the arithmetic of an elliptic curve hidden inside it. That was very unexpected. I am exploring what implications this discovery might have on the question of how many groups there are with a prime power number of symmetries. In a recent paper I wrote with a colleague in oxford, we've understood that my new group can be used to construct groups with $$p^9$$ elements such that the number of groups of order $$p^{10}$$ which map onto those is not polynomial. This goes against the proposal of a conjecture from the 1950s. At the moment it is not a proof that the conjecture is wrong because things might get smoothed out by other groups. But it's a very exciting hint that the conjecture might be wrong. Now I am working on just pushing these ideas to the limit. And basically I am still working on this conjecture which states that the number of groups of order $$p^n$$ when you fix n is given by a polynomial in p depending on the residue class of p. My new symmetry group with the elliptic curve was making me think that it is false but some recent work that I have done with a student is making me begin to wonder whether weirdly things will get smoothed out. I'm in this exciting state of not knowing and wanting to know and I feel it could still go either way.

MS: How is a typical day of work for you?

MDS: I don't really have a typical day of work. That's partly why I really enjoy my work. Last two weeks I have been busy making a programme for BBC about algorithms to promote a year of coding here in Britain. That's been taking me to weird places like an amazing massive supermarket warehouse where all the food is controlled by algorithms and it's like being inside of a computer, seeing all of these algorithms at work. So there is that and then next day I am off to a theatre workshop exploring how theatre can be used to do maths. Today I am talking to you and after this I am talking to a neuro-scientist in California about ideas of consciousness in connection with the book I am writing. So for me the fun thing about this new job, the Professor for the Public Understanding of Science, is that everyday seems to involve a different challenge.

MS: In your website you have two section, left brain and right brain. Do you feel that while doing maths you use only one part?

MDS: I think that while you are actually doing maths you use both part of your brain and that's really important in some ways. That's why I talk a lot to creative people, people doing theatre or choreography or music. It helps me to expand the creative side of my thinking but also helps them to engage a more analytic mathematical side of their brain and they are very open to that. It gives them a new language perhaps to be more creative in their world. I guess in some ways the two sides of the brain were a kind of a neat way to divide the website. But actually recent researchers revealed that the brain is much more plastic than previously conceived. It is true that the language side is located in the left part of the brain and there is evidence that various other functions might have a left or a right side. But ultimately I think the mathematics I do taps into the language side, it will be tapping into spatial recognition, it will be tapping into very analytic logical thought but also very creative and imaginative side. I think to be a complete mathematician requires utilizing every part of your brain.

MS: What is your favourite mathematical result?

MDS : I really think I'd choose Riemann's formula for the number of primes which shows that it's given by Gauss' guess using the logarithmic integral but then these zeroes that Riemann discovered encode the errors either side of that guess. That's an extraordinary result. It's like a secret passageway from primes through to something completely different. I mean these zeroes of the Riemann zeta function, who on earth would have thought that they would be controlling something discrete like the primes. Riemann's formula opened up this new challenge of trying to understand these zeroes. So I think for me the mathematics *I really love are those moment when you uncover incredible connections between things that look like they have nothing to do with each other.* I think my other favourite mathematical result is Cantor's discovery of different sorts of infinities. That breakthrough opened up completely new worlds. It was like counting for the first time but now we are counting infinities. I am a big fan of 19th century mathematics, Galois as well.

MS: Who are your mathematical heroes? Galois?

 Prof. Marcus du Sautoy
(Image Courtesy: Wikipedia)

MDS: I think Galois is such a romantic character. His life story is so extraordinary. He was a great character to write about in my book 'Finding Moonshine'. You can't ask for a better story. Dying in a duel at the age of 20 over love and politics, a revolutionary going against the mainstream and coming with this extraordinary new way of looking at the ideas of symmetry. Although I am not quite sure that he even realized what he had discovered. But if you look at the sort of things he'd already done in his works it is absolutely amazing. He knew that A_5 was a simple group. So I think that Galois is certainly one of my heroes. Also, Riemann. Again he is somebody who is doing such a range of things. He is able to look at ideas of physics to come up with new sorts of views on geometry and also his extraordinary new insight on prime numbers. So I suppose this is why I chose these two as the heroes of my two books. Another hero who features in *The Music of the Primes* is the French 20th century mathematician Andre Weil. I love the ideas he introduced which show algebra at work in the world of geometry. But also he had an interesting historical journey as well.

MS: He was in India for two years as well.

MDS: Exactly. He had a great interest in the Mahabharata and the Bhagvad Gita.

MS: Do you think you will see a proof of RH? Are we close?

MDS: I think that we are one big idea away. I think that the proof of the Weil conjectures gives us a really good indication that we are after an operator to explain the zeroes. The connections now with physics show us the nature of this operator, that it should share similar things in common with operators in quantum physics. It appears to be a random Hermitian matrix. I think there is a good indication that the new thing we need is a new cohomology, similar to the cohomology that helped us to understand the Weil conjectures. Perhaps that's what's missing.

Every now and then there are moves. I was excited when Alan Connes came up with his things but it does seem to be a very slippery problem. You think you have reworded the challenge and that this new perspective will solve it but then things seem to be as difficult to prove in this new reformulation. That's one of the exciting things about maths that you never know when something is going to occur. I never thought that the [Poincaré](#) was going to be the first of the millennium problems to go. That was quite a shock and when Fermat's last theorem got proved that was really amazing. Who knows? And that's part of the joy. You never quite know when the next breakthrough's going to happen and where it's going to come from.

MS: Do you have any hobbies apart from maths? We have read that you are a big football fan, and have said Arsenal is your religion.

MDS: Football is very important to me and I guess music and theatre are the other two important things. I play the trumpet. I started learning the trumpet about the same time I got into maths. It was about the same time at school. I spent a lot of my time playing in orchestras and things. Interestingly I have come back to it. I just joined an orchestra locally here in London where I live. It's really fun. I enjoy the sort of collaborative nature of music making. Sometimes mathematics can be quite a lonely thing. You are often on your own. Maybe you'll have one other person to talk to as you are creating your maths. It's something very nice about creating music together. As I new challenge I've just started learning the cello. I have got two girls who are learning the violin so in sympathy I thought I would learn the cello with them. And

that's fun, a new challenge. I like learning new things. And theatre as well. I used to do theatre to escape from maths. But more recently I found more connections. I recently wrote a new mathematical play called 'X&Y' with another actress and that's been quite fun. I also perform in the play. I think mathematics and theatre have actually got a lot of connections. In fact I just tweeted about a talk I did last week for the royal society which has just gone online which is looking at how science and theatre have been working together quite a lot recently. I do these hobbies to run away from maths but time and again I find maths hiding inside the things I'm passionate about: music, theatre and football, of course. Arsenal is mathematically the most beautiful team to watch.

MS: You have a very [wonderful lecture about secret mathematicians, maths in art and music](). Do you search for such patterns when you are playing an instrument?

MDS: I enjoyed writing that lecture. I realized with all my collaborations with artists across different mediums that so often quite intuitively they were being drawn to things I found interesting mathematically. So I think that *we are all secret mathematicians when we listen to music or when a composer creates music*. Sometimes a composer is very consciously using mathematics. But other times they are playing and then end up finding structures which resonate with mathematics in interesting ways. One of my favourites is the story of Messiaen who used the primes to create a sense of timelessness in his Quartet for the End of Time. He uses a similar idea to the one that makes Indian rhythms interesting because they often play around with missing beats. So you got 7's and 15's rather than 8's and 16's. The interest comes from the fact that these numbers don't mesh. It keeps one interested because you try to work out how this thing is working. I was talking to composers that worked with Messiaen to see how much is was consciously creating these mathematical effects but it turns out that probably he didn't know a lot of maths. He discovered it for himself. He discovered this effect that prime numbers keep things out of sync. I enjoy finding the interesting mathematics hiding inside music. Often when I am listening I am doing this subconsciously, as we all are. I don't think you need to consciously know all the patterns to enjoy them.

MS: How important has your family been to your work?

MDS: I think it keeps you grounded when you have children coming back from school and rioting in the next room. It helps you to come back down to earth from this often rather surreal world that you got wrapped up in during the day. You can get quite lost in this very abstract world. But in some ways I have another family as well. I really feel that one's research students and your PhD supervisor are part of another family. For me whenever I get a new student and I teach them the ways I think and the problems I am working on, it does feel like my family enlarging. There are very few people who really get what you do as a mathematician that you value them very much.

MS: What advice would you give to a young mathematician? Or someone who aspires to be one?

MDS: It's really important that you enjoy what you are doing because it is going to be really difficult at times and I think that helps to cope with things when they are going really badly. You have to get a real buzz out when things are going well. I think you need to be very playful and be very brave and imaginative and creative. I think that those are things that help you through when you get stuck. The exciting thing is there are so many unsolved problems out there. Mathematics really is a living breathing subject because there are so many things that we don't know and understand. There's lot of possibilities

still out there for young mathematicians, mathematics is certainly not finished by any means.

MS: Do you have any plans of visiting India in the recent future?

MDS: I sent an email before talking to you arranging flights to Delhi this summer. Actually I am going to Bhutan to take part in a literary festival. Somebody heard me speaking in Jaipur about symmetry and they thought that would be a really exciting story to bring to Bhutan. But I think the British council are going to get me to give a talk maybe in Delhi on the way back. So I will be in the region in August.

MS: Would you like to give any message to our website?

MDS: So you tell me a little bit about the website. Who are you readers?

MS: Our readers are mostly school and college students.

MDS: I think for me the important thing is to always find ways to enjoy doing your mathematics. Mathematics has a bit technical side to it and sometimes we can become a little bit obsessed with just the technical machinery. It's a little bit like learning a musical instrument. Music isn't just scales and arpeggios. Scales and arpeggios are really great because they help you to play music more easily. But the real thing is the music. So what I would encourage is that teachers in school try and tell some of those big stories. The stories that inspired me. The teacher I had did something amazing for me. I would encourage the students in schools and the teachers to go and find the great pieces in music, the great stories of mathematics and to remember that the things that they are doing in the curriculum are the technical side to facilitate creating and understanding and appreciating and enjoying those big ideas. That often gets missed I feel.

MS: I was inspired to study maths after reading a story about Archimedes. Thank you very much for your time.

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