

## An Interview with Cedric Villani: 2010 Fields Medalist

by Gonit Sora - Friday, September 29, 2017

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**Cédric Villani** is a French mathematician, who was awarded the Fields Medal (considered to be the highest prize in mathematics) in 2010. He is currently Director of [Institut Henri Poincaré](#) and also sits in the National Assembly, the lower house of the French Parliament, representing Essonne's 5th constituency. He was elected president of the French Parliamentary Office for the Evaluation of Scientific and Technological Choices in July 2017. He is well known for his work in partial differential equations and optimal transport. He is also one of the most famous mathematicians alive and has worked consistently towards improving the public's understanding of mathematics. To this end, he has written *The Birth of a Theorem*, a mathematical adventure involving the work that went into proving one of Villani's most famous theorems.

In 2016, Villani was one of the speakers at the Asian Science Camp organized by the Indian Institute of Science (IISc), Bangalore and the Department of Science and Technology, Government of India. Gonit Sora had the honour of doing a video interview with Villani, whose transcript is presented below. The interview questions for Gonit Sora were prepared by Manjil Saikia, Bishal Deb, Pankaj Mahanta and Salik M. Borbora, while the interview was taken by Bishal Deb and Salik M. Borbora. We also acknowledge the following people for helping us organize the interview Prof. G Muges, Dept. of Inorganic and Physical Chemistry, IISc, Prof. Abha Misra, Dept. of Instrumentation and Applied Physics, IISc and the KVPY office bearers at IISc.

A video recording of the interview is currently under the editing phase and we will shortly upload it on our [YouTube channel](#).

**Salik M. Borbora (SMB):** How did you get interest in Mathematics? Was there any particular incident?

**Cedric Villani (CV):** I really don't know. This is a question that everybody asks me and I never really understood why everybody asks. Because you know, everybody does Mathematics at school. So it should be normal that some people find it interesting. It's not like if I had become an expert in space exploration, space exploration is not something that everybody does at school. You have to be interested for some reason. But, as a young kid you are exposed to Mathematics already, so there have to be some people who find this interesting. I cannot remember an age in which I did not find this interesting. As long as my memories go back, I was interested in this.

**SMB:** Do you remember some particular incident or individual that might have inspired you in the initial part of your career?

**CV:** What do you call the initial part of my career? But what do you call the beginning? Like, are you talking about age at 6 or 16 or 20?

**SMB:** Since the time you thought that Mathamatics is your domain.

**CV:** As a child or teenager I never really thought that mathematics was my domain. You know it was may be the field in which my grades were the best, but I had no idea what I was going to do or whether I had a domain or whatever. If as a child you had asked me the question of, "What is your dream job?" it would have been evolutionary biologist, like hunting for dinosaurs. This was certainly the career that most of me dreamed. In those days, anyway I didn't even know that there was a job called "mathematician".

Once in school they asked me what will you do later or something and I wrote engineer. I had no idea that there was research or whatever. And also, I never really worried seriously of what I was going to do later, you know. It was always, well this is interesting, so let's do it. Since it's interesting, let's continue. Of course for this you need people to make you feel it's interesting for sure. So, here are list of people: my maths teachers from age, I would say 13 to 15 in particular. This is an important age, may be 13 to 16 because this is the age in which you learn about mathematical reasoning, what it is about; the books that my father brought back from the flea market, the story of great mathematicians from the past, silly cartoon called Donald in Mathmagic Land, which I thought was fascinating; and these are the early people or event that showed me it's interesting for sure.

In those days my favorite subject in science, was evolutionary biology; which for sure was my great love, but then in mathematics it was the Euclidian geometry, triangle geometry. I was so fond of this. However may be even more important was when I entered higher education institution, Grande École as we say in France, in this case École Normale Supérieure in Paris. And I had no idea what kind of jobs you would do out of there. But it looked interesting, so let's do it. My father was like, are you sure, what is your career you will do after that? I had you see, I don't really care. And this was a very important step for me. And of course to the long list, for a researcher, the most important event in the career of a researcher is a PhD, by far is the most important thing. And I am no exception in that. So, it was really important. In my case PhD was special that I almost quit it even before starting it. I was busy being the president of the students' association/union, organizing all kinds of things. So, for several months I stopped doing mathematics and it was almost the end of my career but then they convinced me to get back into it, and study the subject and then fell in love with the subject from there.

You know young people, let me say something important, young people should not be too much concerned about their future. It's a big disease of the world nowadays that young people are told to secure their future, think about their pension, their retirement, their career, etc. It's a big disease. If you think of your career and so on, you miss the important thing. The most important thing is to do what you are really interested in.

**SMB:** We know from your book that [John Nash](#) is one of your mathematical heroes, are there others that you look up to? Like famous mathematicians?

**CV:** There are many many. The history of mathematics is full of mathematical heroes and geniuses. Okay, when I started my first web page, this was back in 2003; in those days having a web page was a big deal and I put a list of 5 of my heroes. There was Nash, there was Boltzmann, there was Maxwell, there was Mark Kac, famous probabilist, and there was [Alan Turing](#), the father of computer science. And when I showed the list to one of my friends and mentors, who was one of the main expert in Boltzmann equation, he said "Wow! I am amazed to see the similarity between our tastes." But "Usually," he told me that, "I add to this list Faraday - was an example of genius with science intuition without any

mathematical background."

**SMB:** Sir, do you have any special hobbies?

**CV:** No, I have common hobbies, the same as everybody. These include hiking, going to the cinema, reading books and specially comics and listening to music, the same as everybody nothing special. In the old days, I played table tennis in competition long ago and in the old days I played the piano for long time everyday. But, you know really nothing extraordinary.

Villani smiling while listening to a question

**SMB:** We would like to know what a typical working day is for Mr. Cedric Villani.

**CV:** There is no such thing. Some mathematicians, it is famous had their typical day. [Hardy](#), Poincare, Poincare had 5 or 6 hours of work per day: in the mornings some hours, in the evening some hours and that's all. Me, not at all. Sometimes I work during the night, sometimes no work, sometimes it is in some institute, sometimes I act as a director, sometimes I write popular books, sometimes I record on video recorded projects. I, from time to time go to television. From time to time I work on a novel. There is really no ordinary day. Each day is different. And I have a list long like this of things to do every time on my schedule.

**SMB:** Sir, you are said to have one of the best understandings of the Boltzmann equation. Is it possible to say what the equation says in layman's terms? I am aware of the fact that you have spoken about this in the plenary lecture, to some extent, and what are its implications?

**CV:** Boltzmann equation is the equation which allows you to understand and predict the statistical evolution of a gas, either inside a box or in some geometric configuration. If you want to understand, what are the patterns of the air around an airplane, it is quite sensible to use the Boltzmann equation to predict the evolution of the air. If you want to understand the evolution of air inside for instance this part, between the water and here, it also will be quite sensible to use the Boltzmann equation.

What do you mean by statistical prediction? Well, you want to know if there is more molecules here or there. If the particles have tendency to move rather in this direction or in that direction, with percentage/proportions, that is the statistics. And Boltzmann's equation arrive at the prediction spontaneously after you disturb things, equilibration will occur in that air, in that compartment. It had much small profound implications also. It was the basis of Boltzmann's understanding of the arrow of time. The notion of the time evolution, irreversibility. You know if I spill the contents of the bottle around, this will go from a situation very ordered in which the water is inside the bottle to a disordered situation in which the water is everywhere. And spontaneously things always go this way, from order to disorder, that's the arrow of time. And Boltzmann wrote to understand it from a simple theoretical model. So, the implications of the Boltzmann equation are fundamental also in the idea of what is time, what is past and what is future. And then Boltzmann equation is important for engineers. Probably, it is also used for the design of many engines of cars.

**SMB:** Nicely put sir. You have been a very passionate popularizer of mathematics, by various lectures and books. What spurred this interest in you, like popularizing mathematics because normally

mathematicians of your calibre do not involve themselves to such an extent with such activities?

**CV:** Reason number one: It's so much needed and I believe in this. This morning there was very good introductory lecture by the Chief Science Advisor of India and he recalled that the number one challenge of science today is to motivate the young people to become scientists. This is the number one challenge, all around the world. So we have to work on this and I strongly believe in this.

Reason number two: I was trained in a culture in Lyon in which we have this idea that mathematical outreach have to be taken seriously, professionally. It came mainly from Étienne Ghys, who is a famous mathematician, geometer, famous for his very inspiring lectures. He was my neighbor in Lyon for many years and this influenced me a lot. Even when I received the [Fields Medal](#), before that I had been a bit trained, some media training. When people asked me for advice about how to do great communication in science, the first thing I tell them is get some good media training with the professionals.

Number three: I like it. It is fun. You engage in many contacts. You can share with audiences that are much broader. My [TED talk](#) about mathematics was given, it was put online, I don't remember maybe two months ago, three months ago. One million views almost. Of course with a specialised talk you never have such outreach. Okay, I am aware that the massive pop singers, that they have hundreds of millions of views but for a scientist to really have big audiences, impact and share with many people, outreach is the way. And for people it's very important often and so you get strong communication very intense.

Now, there are difficulties. First difficulty: find the right words. Second difficulty: master of the time. Outreach communication, very often, is time constraint much more than the academic communication. Sometimes in radio or TV you have one minute to say the thing that is to the point. Difficulty number three: learn it through your training to repeat hundred times the same thing with the same motivation. In television, people will ask you the same question a hundred times and you have to learn about it like professional singers. They learn to sing there song a hundred times with the same passion.

**SMB:** That was a very nice analogy. So, since you have spoken about the TED talk, there was an instance where it was said that Paris has more mathematicians than any other city in the world and more streets with mathematicians' names. Tale of such thing aren't heard of. Mostly people believe that Paris is the city for art. Why has there been such an important French mathematical tradition according to you?

**CV:** It's a tradition that goes back for a long time and you know traditions in science, like in culture or arts are very stable over time and the period or the time scale stays long. So Paris, in fact France was already strong in mathematics in the 17th century. First half of 17th century, arguably the most important mathematicians in the world were [Fermat](#), [Pascal](#), Descartes and Mersenne, three of them French and other were much influenced by the French. So it was already very strong. And after that, somehow there was a break but in the next century dozens and dozens of great French mathematicians.

When I read the history of sciences, there I see, I think it is insane, why so many mathematicians in the 18th century. I will tell you the main reasons. It was because it was in the culture in the air. It was part of the enlightenment period and people were much motivated about the knowledge, about understanding the truth, about the universal truth. It was in the literature, in the social sciences like the humanists. It was in the philosophy it was so that the mathematics comes with these. Astronomy was very popular in France, extremely important like in the Observatoire in Paris (Observatoire de Paris) and so there was a whole big

group.

And then that group also became influential in politics in those days and people, some of the key scientists (mathematicians in particular at that time) had political influence, some of them were executive by the way in the aftermath of French Revolution. For instance the great Condorcet (Marquis de Condorcet) had to commit suicide but he would have been executive otherwise. And in ways some of the institutions that were started in those days, still to this day, are great institutions for mathematics. École Normale Supérieure, for instance, was really boosted at that time. Seeing that, even Napoleon was member of the French Academy of Sciences. So it was in the air and strongly viewed and powerful and from that time the motion continued.

So roots are in the taste of universality which were already in the French enlightenment and the conception of philosophy and also the fact that the French people, they always have a taste of abstraction and also the fact that the French people, they always have a taste of abstraction and absolute. This is also a weak point of France, you know, there is one to look for the absolute best instead of the practical and pragmatism. Some field it works very well and in some other it is very bad.

And so the French, everybody laughs at them because they always want to tell the whole world what to do. "You have to do like this and this," ahhh. But mathematics is also about finding the good thing of what to do. For instance, after the French revolution the French just started to say "OK. Let's rebuild everything. Let's even change the way that we do the measurements." Then they went on to invent the metre, it was an invention of the French revolution. They said, "It has to be universal for all people. So we have to take the definition out from the Earth. And the metre would be like one over a million of one quarter of the periphery, the circumference of the Earth." But they said, "It's for everybody" but

they wanted to do it themselves. "Let's not wait for the other countries. We have to do it. It is our mission to do it." And they set up doing it. And the English were not so happy, the Americans were not so happy, etc. but in the end the metre worked and everybody accepted it and officially adopted it, except America and a couple of other countries.

But they also did these crazy things; for instance, for cutting up France in various regions, département as we say. The first project was to do it like square grids. Ofcourse, that is too extreme. You had to arrange things. At some point we even changed the way we measured time. They said, "Okay! Let's make weeks of ten days." We did this at some point for several years in France. And even at some point we decided that in the day there would be ten hours for twenty-four hours was stupid. This was very very unpopular. It did not work. We had to go back to the old system. But, you know, with all its drawbacks and good points, this is the French ideal: go for the extreme and the abstract. That goes well with the mathematic taste.

Villani's spider broch

**SMB:** Slightly digressing from academic questions, we are very curious about your dress. We are specially curious about your spider brooches. Would you like to enlighten us?

**CV:** I get, by the way, in fact, questions about my spider, probably everyday in my life and since I started to wear it more than twelve years ago, it is many times already. But after I explained about it two or three

times, I decided I would rather keep it secret in the end because it is a personal thing, personal reason, and also because, you know, people come up with all kinds of poetic explanations. Let's make it this way: now that people know it's part of my dress they offer some, like often when I go to a country, they will offer me some spider in the style of this country and some artists do some for me and so on. This one was made by an artist who has become a great friend. He is from North Africa, he is a Tuareg, they are these tall guys all dressed in blue from the desert. He lives in Niamey in Niger. The stone is called the Cornalian and this is silver. Each of my spiders now often have their story. They reflect human exchanges now that it has become part of my style.

**SMB:** We would like to know how important has been family for you in your work?

**CV:** Family has been very important. I was never formally married but let's say my wife, we have been together for more than twenty years now. So it's as good as married and we have two kids. And it is clear that family obligations are sometimes difficult to accommodate with research obligations, that is for sure. But family life forces you, because it takes time and energy, it forces you to focus on the most important features of your work and also, it brings you back to reality when you are going to be immersed too deep in the problem sometimes. Let's say that, family is important part in your equilibrium, even if as a researcher, for sure you have sometimes to become very densely immersed in your work in such a way that it becomes your number one priority.

**SMB:** We want to know the reason for writing '[The Birth of a Theorem](#)'. Do you think that the book has achieved its purpose?

**CV:** *The Birth of a Theorem* came out from an encounter with a literature editor, a book editor. The encounter took before the Fields medal and that guy, he was very curious.

In the case of Birth of a Theorem, the birth of the book, if I may say, was already a story and in which I was extremely lucky. I was invited in some dinner in an art foundation and it turns out that at the dinner there was an editor, the head of the publishing house who was curious about me. He saw my dress, he thought "This guy, maybe there is a story about him and so on?" So, he inquired and then he found that I am a mathematicians and so on. And he was curious. He tried to convince me to write a book. Those days, I thought of writing books about mathematical outreach, like popular book about the Boltzmann equation or a book about the entropy, who knows, something like that. But he did not want this. He said, "No no, what I want to know is what do you do? What is your life like?" He asked me kind of same question as you, "What is your typical working day?", something like that. "I want to know what's in your head when you think of mathematics."

I was really embarrassed. And I thought and I thought and I thought. I thought, "Okay!" I began thinking of mathematical research as an adventure. So, I should be able to write it like an adventure book, and maybe there should be one action, a project. Project for us is a theorem. Maybe, I can tell the story of one theorem, a complicated one, one that has many ramifications. And focusing on that story I can tell about the whole world of mathematical research. So, this is what I said to myself, "Better describe it as a novel, like adventure novel. Let it be completely faithful, very accurate and it should be about everything, encompass everything and let us not cheat to give the impressions. So, I decided to put the mathematical formulas, and some big words, etc. Without no indication I rediscovered style that was used by Henri Poincare hundred years before me of not trying to explain the mathematical words to force the readers to

focus on the circumstances rather than on the concepts, the adventure, not the content.

Okay, it was radical and in fact it was even much more radical than I thought. People loved the book. The book was a big hit in France, and worldwide to some extent also; varied a lot from country to country. It achieved quite little success in the US but big success in the UK, which is ironic because my career owed a lot to the US and very little to UK. But, it achieved the goal in the sense that throughout the world, the audience understood that this was a book about the passionate adventure of scientific research, not a book about mathematics. And, it was a unique book because of that and because of the style and I think it achieved the goal. It was sold, I don't know exactly, but much more than a hundred thousand copies plus translated in maybe twelve languages. I wrote several other books but none of them comes nearly as high in terms of impact because the book *Birth of a Theorem* was really trying a new way of telling things.

**Bishal Deb (BD):** So, I will take it from here. You wrote your book in French and also some papers in French. Does writing in your mother tongue help you in your intuition?

**CV:** In the mathematical intuition, no. Not really. Mathematical thinking is nonverbal, doesn't depend really on the words. As soon as you are a professional mathematician, you don't really care of the words. But for outreach, it's completely different though. Making even for a popular lecture, so much easier for me, my mother tongue. I find the better words and the better ways to connect with people. For the jokes, the empathy is better and so on. For science, the choice of language doesn't matter so much, but for human emotions, the tongue is very important.

**BD:** So, in the book you have mentioned about Death Note several times and your interest in anime and comics. So, can you name some of your favourites?

**CV:** Comics?

**BD:** Comics and anime?

**CV:** I belong to a generation of French people who grew up with the Japanese anime. They arrived in France first at the end of the 70s and I was like five or six years old, extremely receptive, so for me this was life changing. Those days the big thing was a programme called Grendizer, Goldorak in French. It was a huge hit for French kids at that time and for me as a kid it was extremely important. Later, I again watched all the episodes with my kids, long later. More generally, let me say that as, you know, France is a culture in which the animes are extremely important, we have seen all the movies by Miyazaki. I love also the older one movie, White Snake, the Chinese one, anime, that was before the golden ages of the Japanese anime. There are some very important French anime that I watched as a child, which are masterpieces, the most important being Masters of Time, Les Maîtres du temps.

I watched a number of series. I mentioned some of the series in the book like Lady Oscar. Among the most recent one, I was a huge fan of Death Note. Maybe couple of others but, not as much as Death Note. I am thinking of some other ones. Yes! The Japanese guy who passed away early from cancer, Satoshi Kon. He was a genius. I watched all his anime.

For the comics, well, I read a lot of comics. I even wrote a comics. It was published last year. A comics with a graphic artist in France. But, I read comics from everywhere: comics from North America, Franco-

Belgian authors, manga authors; so enormous amounts. Osamu Tezuka, the great Japanese comics writer is one of my heroes. My kids read so many of his books and me also. And when I went in Kyoto, one of my first visits was to the manga museum.

Among the currently active authors of Manga, may be my favourite is Naoki Urasawa, the author of *Monster*, a masterpiece. In the Franco-Belgian school as they say, I am a huge fan of Goscinny (René Goscinny) who was a genius of scenario, of Franquin (André Franquin) and my usual nickname is the Marsupilami, its is a character from the comics of Franquin, an animal that jumps around everywhere. And also Gotlib (Marcel Gotlib) is a famous author. In the comics world, I am a huge fan of Alan Moore and of all the works of Neil Gaiman. In my TED talk, as you noticed, may be, there is an allusion to the comic *Sandman* by Neil Gaiman. I was actually proud of this line because the theme of the TED conference was dream and the main character in *Sandman* is called Dream. I put it as a line but in such a way that it fits well with the rest of the talk.

Salik Miskat Borbora (left) and Bishal Deb (right) during the interview

**BD:** What is your favourite theorem?

**CV:** Ohh! I never thought about this. There are many possibilities. I could answer that the central limit theorem is of such extraordinary importance or I could answer that the Boltzmann's H theorem is so important, part of my career was in there. May be my own refinement of the H Theorem, I love. It is important for a mathematician to be in love with one's own theorems also. These are the examples that come to my mind. There are so many outstanding theorems in the mathematical world. You know, in science there are so many giants, so many heroes, so many great theorems. When you work in the history of mathematics and science, it makes you, "Wow!". Recently I was reading a biography of Reimann. He was a genius. He, by the way, led a very poor life. He died young, he was often depressed and so on. But his work is of such amazing beauty. So it is hard to choose between all these things, which is the most beautiful.

**BD:** A philosophical question now. Do you think mathematics is invented or discovered?

**CV:** O gosh! Again that question. You have no idea how many times I have been asked this, hundred and hundred of times. I believe mathematics is discovered. It's my gut feeling, it's my belief. But it is as religion, there is no proof and there will never be. It is a metaphysical problem. But I believe that mathematics exists even without us.

**BD:** What do you feel are the great problems in mathematics that you think will pave the path of mathematics in the near future?

**CV:** Without any hesitation, two of the most important fields nowadays in development of mathematics are the interface of mathematics and computer science and problems related to security, encryption-decryption, but security in general, and what does it mean hundred percent safe, what is a proof that the thing works? And the other I am thinking of is the mathematical biology. But, you cannot say there is one problem there. But you cannot say there is one problem there. It's hundreds of problems together.

These are current developments and great work of many problems together and yes better mathematical

understanding of the great algorithms, I think is also key. For instance, now a days is the time of development of artificial intelligence. There is certainly too much fuss about it by the way, but there is some progress and for sure, it is at the same time frustrating and important that we don't really understand why they work so well. You know, the current algorithms in machine learning are not the ones that people thought about, twenty years ago or even in some cases, well they had already known about these algorithms and they said that okay, they don't really work. In the end they work because there were certain thresholds that were met in terms of capacity and things became much more effective. We don't really understand them. Very general principle in big data that some numbers erases all the rest. If you have big data set, the most important quality is that it be really big; not that it's very reliable, etc. We need concepts to understand this. It's an empirical construction we don't understand it really. And more generally, what we do in all these artificial intelligence business is very much empirical. Some clever algorithms and then you know, doing some cuisine. As a good french mathematician, I believe there have to be some fundamental principles behind waiting to be discovered.

**BD:** In your book you have written about your love for tea, I want to ask you if you have tried any of the Indian variants, Darjeeling or Assam tea?

**CV:** Oh! Darjeeling is very popular world-wide; it's very very common also in France. Yes, this we know. When I go to india (don't go so regularly, since this is only my second trip), the one thing I have very regularly have is the masala tea. Because this, you don't get in Europe.

**BD:** You are not only a mathematician, but also an administrator as the director of Institute of Henri Poincare. How has this phase of your life as an administrator been?

**CV:** Very important. It has kept me very very busy; so very busy. It's running about not only administration but what it is to motivate a team, to do long term projects, to search for the money, to go and find the people, the support, everything. I had to learn all these, you know, by working and I discovered that projects in this are, maybe, even longer than research projects. Longer than research projects in mathematics for sure. When I started my job I thought, I am going to do one term, it's a five year term, do some good job and get back to my research. After five years, I understood, it was only the beginning. Now, I am around the middle of my second term; and I think it took me seven years before I had the complete picture; that means, the right project, the right funding, the right people, the right image of what would be accomplished during my time as director. And it involved going every where to find millions and millions in support which is not easy for fundamental research. It meant getting the right ideas and support for extending the institute, extending the mission, and so on and talking and meeting so many people long term. I had no idea about all these when I started. I was known to be very efficient as an administrator. I had been vice president, vice director of my laboratory and I had served in some committees, some people were aware that I am more efficient than average as a scientist for administration. But, I never imagined that it would take that amplitude and that amount of work. It's always better when you start big projects, to be unaware of how big it will be.

**BD:** Does your institute have any programs where young Indian students may possibly apply?

**CV:** So, there are strong connections between between the French and Indian sciences. There are strong connections in mathematics but also in all sciences and there are some special agreements for French and Indian scientists to work on exchange programs. From my institute, we operate with all kinds of countries

and we are not so keen about special agreements with institutions. We feel it is more about people like this professor, that professor, let's do something about Institute Poincare and so on. The job of Institute Henri Poincare is to run (one of the jobs let's say) is to run thematic programs which change every three months but which cover all subjects of mathematics and theoretical physics and in each of these programs there have to be some young people. We do some special tutorial sessions for them, we send them into training, schools you know, before the program so that they can benefit better, give them some support, and so on. And its only for short term like three months period. It can be very important. I did find some of my research subjects in this kind of program when I was younger. So, all young participants are encouraged. When they participate in this, it has to be through recommendation of some professor, some organizer and so on. It can be life changing.

**BD:** What are you currently working on?

**CV:** Currently working on many things, too many things, too many. At institutional level, we just founded, kind of foundation for my institute to get private money, it is a big thing, we have to work it out and continue the development. It will be one of the most important files this year. Also, we are preparing broad audience conference about the future of mathematics and computer science and, we are preparing for the celebration of Claude Shannon because 2016 is the hundredth anniversary of Claude Shannon, of his birth.

I am working at the associative level, I am also president of association. It's an association which involves art like music and computers and new instruments which are designed by exceptional self taught artists and engineers and working with disabled people because these instruments are very good for disabled people to interact with. So we work in collaboration with institutes working for disabled people and so on. I need to get funding for this and this year, is the year in which we should receive our new facilities. We have to find the money for the rent and big things.

As a mathematician, I am preparing a lecture about recent developments in a field that I contributed to found which is called the non-smooth theory of Ricci curvature bounds. I laid the first grounds together with a couple of other people of this field twelve years ago and it has evolved into a big thing and last year, two young mathematicians from Italy, proved a big result in that field, a result which I myself dreamt to prove. Of course I am disappointed that I could not prove it myself but I love the result and I will myself explain it in the Bourbaki seminar which is an important series of seminars. It's a big thing preparing this, it takes quite some time; you have to prepare a beautiful text explaining in very clear terms what is a proof, what is solved, put it in perspective and so on. Okay, so that's one thing. I am working on a project in geometry that will be kind of a departure of what I did before, more elementary but in all this, we'll tackle some problems about geometry of surfaces. Let me not say more about it except that geometry of surfaces is very old, very simple field and still full of unsolved problems.

Also as an author, I am currently working on an abecedary, you know, a book that will talk about mathematics as a kind of portrait with selected words. Each word will be developed with ten pages, what it means for mathematics and for me. A is for analysis, B is for Boltzmann, C is for Collaborator, D is for detective, E is for Europe, F is for Fields Medal, G is for Greece and so on, so that at the end of the twenty sixth letter we have a complete picture of mathematics and its history and also how I feel about it. And, last but not least, I am working on a scenario of a new comics.

**BD:** Since you mentioned Bourbaki, I would like to ask you if your work has been influence by the Bourbaki style?

**CV:** A little, but not that much. But Bourbaki influenced the whole world you know, they set up new notation which were influential, new concepts, new ideas. I learnt topology for instance in a quite Bourbaki style. Later I adopted rather more pedestrian approach to this, but for instance, I was trained in the idea that metric topology is just a particular case of general topology. Now I think this is too extreme and I don't care about non-metric topology. It's important in some areas of mathematics I concede, especially like algebraic geometry, but if I wanted to say what is most fundamental, for me in topology, etc. it's metric space.

What influenced me though, I think is the idea of writing everything. When I wrote, I wrote a big book on optimal transport, may be almost one thousand pages long, and writing this was really like happened to the Bourbaki people. "Let's write some lecture notes. Oh but this reference is not good, let's rewrite it, this okay we'll have to rewrite it better, oh but there is something more fundamental better to redo it." and the same process I went through and what had to be just hundred page lecture notes, became a one thousand page reference book in which I rewrote everything from the ground to the end and at each time, working and asking which is the most natural generality, which is a good notation, which are the good axioms and so on. That is very much the Bourbaki spirit. When you work on a problem, not just try to solve that problem, ask what is the right setting? The right point of view for everything?

Villani while answering a question

**BD:** You mentioned elsewhere that you reply to every email that you receive. Even our editor was surprised to receive a very prompt response from you about this interview. Is there any particular reason for this? We know that you are a very busy man.

**CV:** I reply to almost every mail I receive. There are rare examples in which I decide not to reply, it happens for instance that I receive an email from a person that is clearly distraught. There are many people in the world who are, "crackpots" of some kind. Some of them are gentle and you feel okay. They are a bit strange but let's answer. In other cases, you don't want to answer and people are clearly distraught and it may be a disservice. But indeed, I reply to almost every email that I receive. This is such a burden. Somehow I feel it's my duty you know, people, they see me as a public figure, they write me often, they put a lot of importance in their email, I have to reply and sometimes also, you know, you get an idea by replying. You know, everyday I receive questions from people, etc. Sometimes these are very good questions, the effort of writing a reply makes me think oh, that makes me think of some thing; there is a link may be between this and that and so on, and it's a part of my general idea that you should never neglect some possible way, some possible track. You know, this is the rational answer that I give, but may be truth is I'm a bit crazy.

**BD:** In a recent Scientific American opinion piece, there has been some criticism about mathematics popularization where the author opines that mathematics is the realm of a select few "elites", he calls them, and the normal person should not be forced to learn higher mathematics. This seems to be in contrast to your mission of popularizing mathematics for the masses. What are your views on such criticism? Have you faced similar criticism about your work?

**CV:** I did not really face such criticism. This is old debate and I think, this is a grumpy debate, there is no point in arguing like this. I mean, you know, everybody has to learn some philosophy in school just to have an idea of the efforts of mankind to make sense of the world. Nowadays, mathematics has changed the world so much, that everybody has to have a view of what is mathematics and having a view of mathematics doesn't mean just hearing to talk about mathematics, it also means doing some mathematics. And now, come on, they talk about higher mathematics, what people do in school and high school, this is not higher mathematics, come on!

Some people, it is true, will never be able to get it, in the same way, some people cannot learn to read. It's true. Some people have a distinctive organization of the brain such that they will never read fluently, and some people also have a particular organization of the brain such that they will never be able to understand what is a proof. But, for most people, it's just a question of effort. You can do it people, if you put a little heart in it, the same way if you can learn to play football if you put a little bit of effort and so on. But one has to do a bit of the effort.

And the point with mathematics is that, mathematics teaching is not just for future mathematicians. It is for everybody who is a bit curious and who wants to understand what is rigorous reasoning, what it means. After this, you can forget it, it is really some effort. You know, the ancient Greek philosophers, they considered it, it was mandatory to learn some mathematics. Plato, he explains, "You have to learn about mathematics and it's important to understand about the world and to understand what is the meaning," for instance, "about the meaning of equality of concepts" and so forth. Abraham Lincoln, used to say, it was by learning mathematics that he understood what it means to prove, he was a lawyer, for him proving was important. These are people who understood that mathematics is not just for mathematicians, it is for everybody who wants to understand critical aspect of human thought that has been part of the revolution of mankind.

**BD:** Would you like to give any advice to aspiring mathematicians and young students who are watching this interview?

**CV:** Just do it! That's the advice. Never give up. If you cannot solve this problem, you will solve the next problem and when you have solved the problem, move to something else. Always on the move, never give up. And never be too sure of what you want to do. When I was a teenager, I thought geometry was the coolest thing in mathematics, Euclidean geometry. When I was maybe eighteen years old, I believed that algebra was the most beautiful thing. Now, algebra is a whole subject in mathematics, the one that I understand the least, totally obscure to me. I went into analysis, it was unexpected; I went into partial differential equations, I never expected this before; even worse, I went into mathematical physics even though I was not so fond of physics; now I find physics is so much more fascinating when you also know the mathematical side. So you can never be too sure of what we are going to come up. My most important discoveries in mathematics, it was by solving some problems that I was not even aware of, say, one or two years before I could solve them. So, never have too precise ideas of what you are going to do.

Villani's message for Gonit Sora

**BD:** Would you like to give any message to our website?

**CV:** What do you call a message? For the website, I wish the best of luck and whenever you have a

project, be it website or your research career or your institutional project or whatever, always the encounters will nurture things, and always there will be moments in which you are very lucky; but it is very important to understand when you are lucky and you have to exploit it. Many people and many projects you can be lucky and not notice it, then you go past great opportunity. Recognize when you are lucky, is one of the most important things in life. I am being a bit dramatic now but this is true what I say.

**BD:** We would ask you to give an autograph for our website.

**CV:** Yes, this I can do, it's my job. Okay!

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