Interview with Srinivasa Varadhan

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R Sujatha

Srinivasa Varadhan

Srinivasa Varadhan, known also as Raghu to friends, was born in Chennai (previously Madras) in 1940. He completed his PhD in 1963 in the Indian Statistical Institute (ISI), Calcutta, and has been in Courant Institute of Mathematical Sciences since 1963. An internationally renowned probabilist, he was awarded the Abel Prize in 2007 and was honoured with the National Medal of Science by President Obama in 2010. Sujatha Ramdorai followed up an e-interview with a free wheeling conversation in Chennai on January 10, 2012, where he spoke on subjects ranging from his career and mathematics to science education and mathematical talent in Asia.

Sujatha Ramdorai: Congratulations on being awarded the National Medal of Science. I know that this comes after various other honours, including of course, the Abel Prize, so there might be an element of having got used to such events. Still, what were your feelings when you heard the news and when you actually received the medal from President Obama?

Srinivasa Varadhan: It is always gratifying to be recognised for something that one has done. I was happy for myself as well as for my family, especially for my seven-year-old grandson, Gavin, who was thrilled to attend the function and meet President Obama. It was a graceful affair and the agencies of the government that ran it did a wonderful job.

SR: The article that appeared in a leading Indian news magazine, Frontline, after you won the Abel Prize, generated a lot of interest in India (http://frontlineonnet.com/fl2407/stories/20070420001909700.htm). I would like to dwell in detail on some aspects mentioned there .... For instance, the article talks about your father and his other student V S Varadarajan .... Can you tell us a little more about your childhood, the environment at home, your schooling, etc.

SV: Varadarajan's father and my father knew each other professionally as they were both in the field of education, but V S Varadarajan was never a student of my father. We grew up in different towns. My father was a science teacher and became a headmaster at some point. He was in the district school system and was transferred periodically to different towns within Chingleput district, which surrounds the city of Chennai. I was the only child and grew up without the company of any siblings. But we had a close extended family and always visited or were visited by many cousins from both sides during vacation time. I am still close to my cousins and keep in touch with them. My schooling was always following my father around. These small towns had only one school and my father was the headmaster. I had no choice but to go to that school. Being connected had some privileges but also some pitfalls. Any mischief in class was quickly reported! I was a good student in mathematics. But I did not like memorising facts, a skill that was needed in other subjects like history or biology. I did very well in mathematics but was only reasonably good in other subjects.

SR: And your college years, and your entry into Indian Statistical Institute (ISI)? The ISI is now getting special attention and funds from the Indian

government in recent years and has been declared an institution of national importance. What was it like to be at ISI in the early 1960s?

SV: In those times, we had two years of "intermediate" before becoming an undergraduate. It used to be (11+2+2) for a degree and (11+2+3) for an honours degree that automatically gave you a MA degree instead of a BA. After 11 years of school, in 1954, I had to go and stay with my uncle in Tambaram, since there were no colleges near Ponneri, about 20 miles north of Chennai, where my father was the headmaster of the high school. Just when I finished my "intermediate", my father retired from this position in 1956. He then moved to Tambaram, where his brother, whom I had stayed with, had a home. My father built a house and settled down there. He worked as the headmaster for three more years at a local high school in Tambaram before retiring in 1959. I did very well in mathematics, physics and chemistry but performed only above average in languages. I had taken Tamil as my language and it was a high level programme involving classical literature. Whereas students taking French or Sanskrit started at a low level and could easily get a high score in the examinations. Since these scores were used to determine admission in the undergraduate or honours degree programme, these students had an advantage over those who took other (vernacular Indian) languages like Tamil, Telugu, or Hindi. I wanted to do an honours programme that consisted of a small class of 10–15 students and got special attention from the departments. I tried to get admitted to physics, chemistry and statistics programmes that were offered at three different colleges in Chennai. Competition for admission was tough, I was admitted into the statistics programme, but was denied admission to chemistry. I took statistics before the physics situation was still up in the air. Once you accepted one programme, your application to other programmes would not be considered seriously. I really enjoyed my three years at Presidency college. I commuted from home for one year and joined the hostel for the last two years. Our class had 13 students. We were a very close knit group and stayed together for every class for three years. 11 of us are still living and we still keep in touch and meet each other when we get a chance.

I did very well in the honours programme. There was only a year of English and no other language requirements. We studied only mathematics and statistics. It all came very easily. I could just take the examinations with no special preparation and did not have to work very hard. After completing my honours programme, my family wanted me to compete for the Indian Administrative Service (IAS). I was more interested in studying statistics and working in an industry. In fact, I was too young to sit for the IAS exam and so I convinced my parents I would try to do research for a couple of years and would sit for the IAS when I became eligible. So I took the exam for ISI and was taken as a research scholar.

My initial choice was to do industrial statistics, so I was put in touch with a faculty member who did that. I struggled for a few months. It did not appeal to me as something I wanted to do for the rest of my life. It was then that I met Parthasarathy and Ranga Rao (although I met V S Varadarajan as well but he left for the USA within a few months) and that changed my life. I started learning some modern mathematics. My training so far had been mainly in classical analysis. We started working on a couple of problems on subjects we thought would be interesting and went ahead. Those were exciting times.

ISI was run like a family enterprise. Mahalanobis was the titular head. But the rumour was that it was Rani (his wife) who really ran it! Dr Rao was the head of the scientific staff. He would have to listen to Professor (as Mahalanobis was referred to), but would not always opt to follow it. We were protected by Dr Rao from the Professor who could sometimes act in strange ways and was not too fond of abstract Mathematics. But we were left free to work on what we wanted. Dr Rao would listen to what we were doing, and encourage us. We felt very well-supported by the Institution. However, one big disadvantage was Calcutta, especially Baranagar, where ISI was located, was an area that was totally inaccessible from other attractive parts of the city. It was congested, dirty and chaotic. We, especially those from the south (of India), could not think of raising a family there. Later, the Institute built apartments for the faculty members. But it could not ease the sense of isolation.

One serious problem with ISI then, perhaps even now, is the large number of support staff compared to faculty and research staff. As part of the Marxist ethos, everybody is a worker. The workers are unionised and there have been too many confrontations. But scientifically, it was very interesting with a constant stream of distinguished visitors who would come and spend a few weeks. There were lectures by visitors as well as ample opportunities for young scholars to meet them informally during tea sessions that took place twice a day, at 11.30 am and 3.30 pm respectively. The senior faculty was always around.

The Institute also had J B S Haldane, who was literally a towering figure with a cigar in his mouth. He was always at the tea sessions and had interesting things to say about almost everything.

SR: This four year programme is being reintroduced in some selected institutions in India, and there are mixed feelings ....

SV: Even in those times, the honours programme was selective and tightly regulated, in the sense that only a few selected institutions were granted permission to start these programmes.

SR: You got your PhD degree at a relatively young age (23 years old). Kolmogorov was one of your thesis examiners and wrote a glowing report ....

SV: He visited the Institute in 1962 for about six weeks. He spent three weeks in Calcutta and then we travelled with him from Calcutta to Bhubaneshwar, Waltair, Chennai, Bangalore, and Cochin where he took a ship back to Russia. He was one of the three examiners for my thesis. I gave a talk on my thesis when he was in Calcutta. I talked for too long. The audience became restless and some left immediately before Kolmogorov, who stood up to comment, could speak. He threw down the chalk and marched out angrily. My immediate reaction was "there goes my PhD". A group of us followed him to his room and I apologised profusely for talking too long. His response was "I am used to long seminars in Moscow. But when Kolomogorov wants to speak, people should listen." Anyway he took my thesis and went home. There was no response for several months. Then K R Parthasarathy went to Moscow and he was given the responsibility of nudging him, which he did. A report came some time later, in time for me to graduate in 1963. Although it was confidential and written in Russian, there was an English translation and I got to see it. He had said some nice things and ended with something like how I was someone "towards whose future the country can look forward with pride and hope".

SR: Can you reminisce a little about the mathematical scene in the country at that period? There was ISI and of course, there was Tata Institute of Fundamental Research (TIFR). People in these institutions were doing tremendous work that made the world sit up and take notice of mathematics research emerging from India.

SV: Those days there was only one Indian Institute of Technology (IIT). The best minds went to pure sciences and mathematics. There was no computer science, not much to speak of. The honours programme to which only the best of the two year "intermediate" students were admitted was a magnet that attracted the very best. They were small classes and the programmes with a major and often a minor offered with limited number of seats in selected colleges produced a good group of graduates. Many went into IAS and other government services and many went into research, at ISI and TIFR as well as a few other places. The attraction of IITs and the abolition of the honours programme destroyed this source.

Srinivasa Varadhan and R Sujatha

SR: Today, mathematics is establishing connections with a variety of subjects ranging from physics to economics; how do you think mathematics education should reflect this trend?

SV: In general, I feel that it is not a good idea to give students a time table; be told what they should do .... For example, majoring in physics; it should involve a few core courses and a wider choice of auxiliary courses that should include areas in which one is not majoring; a broad perspective is needed for a human being. An economic major or history major knowing how the human body works is not a bad idea ....

SR: The Abel Prize citation notes that "Art of large deviations is to calculate the probability of rare events ...". When did you actually start working on this theory that you and others have now built up as an edifice of depth, awe and great beauty in mathematics?

SV: To me, beauty in mathematics comes from unification and simplicity. When a simple underlying idea

can explain many complex things, it is almost like watching a magic show. When Cramer started on large deviations, he wanted to derive precise estimates on the probability of some rare events for use in the insurance industry. He showed us how to do it. Then Donsker had an idea of how some function space integrals can be estimated through what we would now call large deviation ideas. But it was slowly dawning on me that entropy controlled all large deviations. Almost all large deviations are shadows of "entropy", and although the shadow may not immediately reveal what is behind it, we can now perceive it. I started working on problems in the area from 1963 when I came to Courant. I rediscovered in my own terms what people had done before, and ideas have come from statistics, thermodynamics, convex analysis, combinatorics as well as coding and information theory. It took me several years before I could fully understand the beautiful structure behind it all and the role played by entropy in creating it!

SR: This brings me back to the earlier comment on connections. Can you talk a little on how you came to recognise all these ideas as being linked to entropy? Was the ISI background helpful in this? Or did you embark on a whole new journey of discovery in Courant?

SV: I had learnt a little bit of information theory in ISI thanks to K R Parthasarathy, whose thesis was on this. When you do Cramer's theorem, entropy is hidden, you do not see it. But when you do Sanov's theorem, you see it; it is not very different from Cramer's theorem and entropy is much more evident there. You work on a special case, and do some more examples, then do the general case; and you see a pattern emerging. It is also partly because of how I came to do these problems. The way I came about it was thinking about specific questions, trying to understand how large deviation methods could be applied, and then seeing the larger picture and the underlying unity .... I did not do things the other way round; that is reading all about large deviations and applying them. I am not a good reader; I like to work on problems and to learn and develop the theory as I go along.

SR: Were there any clear tipping points or turning points in your research career? Any "eureka" moments?

SV: Every problem has a "eureka" moment. A problem you can solve right away is not fun. It must be a tough nut to crack. Like putting a big puzzle together. You have a vague idea of how to solve it and face many hurdles. Finally after a long time and many attempts, the last one is overcome. That is a "eureka" moment. It has happened many times.

SR: Probability is now a branch of mathematics that straddles different areas within and outside of mathematics. It has enormous applications, yet is recognised within the pure mathematical firmament .... Would you like to share your views on this and talk a little about its evolution in broad terms?

SV: After Kolmogorov axiomatised probability in the 1930s, it is now viewed as a branch of analysis. But it brings to analysis and to mathematics, a point of view and intuition that comes from the use of randomness in many other different areas like statistics, computer science, physics, etc. As more and more of these connections are revealed the importance of probability within mathematics has grown. These are links that have made it more central.

SR: What are your views on the perceived dichotomy between pure and applied mathematics?

SV: I would like to argue that there is no such thing as pure or applied mathematics. There is just mathematics. Would you call algebra or number theory pure or applied?

SR: I was raised in a culture to believe they are "pure".

SV: But they are being applied today in so many different areas.

SR: (Laughing) True! But pure mathematicians rarely understand how or even think it is worth their while to do so.

SV: That is a pity! You don't have to go into details but it would be good to try and get a vague idea.

SR: Of course, probability also got into the public lexicon due to its connections to mathematical finance and the recession. What are your views on this?

SV: Probability is a mathematical tool. You can compute probabilities from a model. The answers you get are only as good as the model. The financial meltdown is probably more likely due to greed and incorrect modelling.

SR: Another phrase that is part of this lexicon is the "Black Swan" phenomenon. How would you view

it from the prism of the theory of large deviations?

SV: I have not read the book. Rare events do occur every day. Someone always wins a lottery!

SR: You have been in the Courant Institute since 1963. How would you compare the research environment there at that time to your prior experience in India? Were there times when you thought about returning to India or building stronger links with institutions in India?

SV: In 1963, Courant Institute was the Mecca of PDE and applied mathematics. Many people in these areas passed through Courant every year for a few days. We had Kurt Friedrichs, Fritz John, James Stoker, Peter Lax, Louis Nirenberg, Jurgen Moser, Joseph Keller and Monroe Donsker all under one roof. There were 50 visitors on any given day, with about 30 visiting for the whole year. There were half a dozen seminars on any given day. I had not seen such an active place before and it was a shock. It was also a bit intimidating and I was not totally confident that I would succeed in this research career. The idea of going back was initially there. My original plan was to return after three years, but I married Vasu after one year and had to wait for four years for her to get her degree from NYU, and then we had our first son. By this time, I had been here for six years and was an associate professor. Going back to India, particularly to Calcutta, was not that attractive. Ranga Rao, Varadarajan and Parthasarathy had left. NYU and Courant seemed much more convenient.

Sometimes I do wonder what would have happened if I had gone back. I had always profited by interacting with others in different areas, often looking at the same thing with different perspectives. Would that have continued in India? I am not sure.

SR: I would like to turn now to your recent connections to India. In the last decade, you have been closely associated with Chennai Mathematical Institute (CMI) and in recent years with the Infosys Foundation. Please tell us about this.

SV: Even though I have settled down in the US, I have strong family ties to Chennai. While my parents were alive, I would visit India every few months. I had kept in touch with the Institute of Mathematical Sciences (Matscience, Chennai), even before Seshadri came there (in the early 1980s). Then Southern Petroleum Industries Corporation (SPIC; which funded a mathematics research Institute in Chennai) was started and then evolved into CMI. As for Infosys, it is a great idea to award significant prizes in different areas of science every year. It is good that it is done by a private foundation rather that the government. When the Infosys foundation asked for my help in the selection process in the mathematics category, I was happy to do it.

SR: What are your views on the state of higher education and research in India? A SWOT analysis.

SV: We do a great job training professionals, especially doctors and engineers. We do not do such a good job in mathematics and perhaps in some other sciences as well. The universities for the most part, leave undergraduate teaching to affiliated colleges where the quality is uneven.

Science education suffers due to lack of quality faculties. The best brains are drawn into IIT medical schools and Indian Institute of Management (IIM) which lead to financially rewarding careers. In mathematics, a country like ours needs to produce good PhDs, be aware of the current ongoing work in large numbers like a few hundreds. We are nowhere near it now. We do not have enough people to act as mentors. What is more serious, we do not seem to have a plan (I hope I am wrong) of how to achieve it.

SR: You are aware that fewer students are pursuing the pure sciences in India than before. The perception is that research and an academic career are the only possibilities if one is interested in mathematics.

SV: This has to be changed. One of the things I remember while I joined Courant was a small booklet "*Careers in Mathematics*" which had interviews with a wide range of people, not necessarily academics, who were using mathematics in different careers. We need such awareness. There are expanding opportunities for mathematicians, which should be compiled in an attractive booklet and circulated widely maybe among undergraduates and maybe even in high school.

SR: Can you share your experiences in working and collaborating with others? One other quality that people never fail to mention is your generosity in sharing insights and ideas with others.

SV: I enjoy thinking about mathematical problems. It is a challenge. It is fun to share it with someone. Collaborating with someone can be a rewarding experience.

The other person often has a different perspective and there are constant discussions back and forth. I have worked with many different people and it has always been a rewarding experience.

SR: Are there any lessons we should be learning from the way things are done in other parts of the world? There is a change globally in the way research was done in the second half of the last decade, and now. Many Asian nations are emerging as forces to reckon with ... yet.

SV: India seems to be far from making the big leap. Unfortunately, education in India has become too politicised. States are in charge of higher education. They run the universities with a political perspective rather than a scientific one. Colleges mushroom with no checks on the quality of the personnel or facilities. Some of them are run purely for the financial gain of the investor. While a few Indian Institute of Science Education and Research (IISERs) and National Institute of Science Education and Research (NISERs) are doing an excellent job, they can only make a small dent in the huge need for good quality higher education.

When I was a graduate student in Calcutta, there were many students from Southeast Asia who were taught in ISI. Students from Vietnam, Korea and Japan have done well while there are occasionally good students from the Philippines as well. The training in mathematics is not consistent as can be seen in Iran. It would be good if countries such as China, India, Japan and Korea collaborate to rise the standard of mathematics training in other Asian countries. Students coming to Courant are among the best. There are also a lot of students from South America, Europe and China. The students, including those from India, are very well-prepared.

SR: You are said to be deeply influenced by the Tiruppavai (devotional poems in Tamil, composed by Andal, a famous woman poet of the 8th century). Is it the poetry? Or the depth in its interpretation?

SV: I like Tamil poetry in general. I studied the language in school and college. I enjoy music as well. Thiruppavai embodies a nice combination. I would not say I was deeply influenced by it.

SR: Thank you so much! It has been a great pleasure doing this interview with you.

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Sujatha Ramdorai is currently holding a Canada Research Chair at University of British Columbia. She was a Professor of Mathematics at Tata Institute of Fundamental Research (TIFR), Bombay, India. Her research interests are in the areas of Iwasawa theory and the categories of motives. She served as a Member of the National Knowledge Commission of India from 2007 to 2009.