



# Mathematical minds

**Nalini Joshi\***

Nalini Joshi is an applied mathematician researching nonlinear systems. In addition to her role as President of the AustMS, Joshi is also Head of the School of Mathematics and Statistics at the University of Sydney. For this, the first of a series of interviews with Australian mathematicians, the *Gazette* spoke to Joshi during a break at the 7th Australia–New Zealand Mathematics Convention (December 2008), to talk about her life and mathematical career.

## Early life

*Gazette:* Were you born in Australia?

*Joshi:* No, I was born in Burma.

*Gazette:* When did you come to Australia?

*Joshi:* In 1971, when I was twelve. My family migrated to Australia. We came to Sydney — I remember landing at the airport and being amazed. My father had a total of \$4 in his pockets for a family of four because you are not allowed to take foreign currency beyond a very small amount out from Burma. But it was really good that a family member of a patient of my father's in Burma knew that we were coming. He came to the airport every day to check which flight we were on. He took us to his home until my father started his job and we could afford to pay rent.

*Gazette:* What did your parents do?

*Joshi:* My father was a doctor and my mother was a housewife.

*Gazette:* Did your father get accreditation to work as a doctor in Australia?

*Joshi:* Yes. It was just after the white Australia policy ended and doctors were very much wanted. He went through a system that was considered good enough, because it was the colonial British system in Burma.

I remember he told us the story of how he was hired. He was conscripted into the army in Burma, because they didn't want professionals of ethnically different origin from the Burmese to prosper, so he knew quite a lot about how to treat people in a medical emergency and in war settings. And he said when he came to a district hospital and he was interviewed the first thing they asked him to do was a tracheotomy, where they cut a hole in the throat to let somebody breathe. He knew how to do that because he'd done this hundreds of times on the battle field — he got a job straight away. My parents were born in Burma, but my grandparents were ethnically Indian. The Burmese Government, which came in through a coup

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in 1962, wanted to make Burma predominantly Burmese, they wanted to get rid of other ethnic groups. They conscripted professionals in the army, paid them very little, and didn't promote them, among other things. That was the major reason why my father left Burma, because he felt discriminated against.

However while he was in the army, I had the best time of my life because we lived in the countryside in various far flung outposts near the Golden Triangle Region which is bounded by China, Laos and Thailand. I had a very adventurous and free childhood there.

*Gazette: Any brothers and sisters?*

*Joshi:* I have a younger brother who was trained as a classical musician. He now works in arts administration for the Australia Council.

## Education

*Gazette: Were you encouraged to do mathematics at high school?*

*Joshi:* I get bored very quickly. I remember that at school I was always a chapter behind the others in the maths class, and when I needed to I would catch up. I don't know if anyone encouraged me, or just let me go at my own pace. Those days, I never knew anything about mathematics competitions or maths camps. It was only when I got to university that I found out about them. So in a sense, I guess it was benign neglect. It was fine because I could go at my own pace.

Also, the first three years of high school I attended a girls' school, then it merged with a boys' school. In the first three years I didn't have that factor that they say is so important in influencing girls to turn away from maths. We didn't have the boys creating that peer pressure to turn you away.

I just enjoyed maths so much at school, and I could tell that I could do things faster than some of the other people seemed to be able to. And I loved explaining to the other students in class. So I knew that this was something I could do and wanted to do. But in fact, when I went to uni I wanted to do astrophysics. I was in love with astronomy and astrophysics and I actually wanted to become an astronaut. That's what I told my career advisor at school, and she said 'That's a bit unrealistic, dear'.

When I went to uni, I did first year physics and that's when I found out that I couldn't be a physicist; I have an empty set for physical intuition. So I went off into applied maths instead. There I could understand everything. I really wanted to work on problems that would have an impact on understanding the world.

As I said, I was in love with astronomy and astrophysics, and there was a lecturer, Ted Fackerell, who was a relativist and he had just started to become interested in integrable systems theory, who became my honours supervisor. He had this romantic idea that you could think about the interaction of two black holes in the universe like the interaction of two solitons in integrable systems. This captured my imagination and I started learning more and more about soliton theory.

When I went to do my PhD I chose Martin Kruskal who was the discoverer of solitons and started the whole field rolling in the sixties. I went to Princeton to work with him. I started a very long collaboration with him which was wonderful, and I've been in that field ever since.

*Gazette: What year did you complete your undergraduate degree?*

*Joshi:* I graduated in 1982. I went to Princeton in August/September 1982.

*Gazette: And your PhD?*

*Joshi:* It was awarded in 1987.

My PhD supervisor died a couple of years ago. He was an amazing man. He was a strong, very real, idiosyncratic person. I remember the first conversation I had with him when I first met him. It had to do something with chaos. We were discussing a topic I could work on. I said, 'chaos as in the television series?' So we started talking about television series and our favourite TV programs.

He used to wear two holsters, and they were full of pens, pencils, letter openers, chalk holders, spare leads, spare erasers, magnifying glass. Anything you might want in terms of stationery, he had it in one of those holsters.

*Gazette: How did you end up with him as advisor?*

*Joshi:* As I said before, I got interested in soliton theory, so I looked up every paper I could in that area. And I saw that in a lot of them, although he wasn't an author, he was mentioned in acknowledgements, for having stimulating discussions with. I knew he was the inventor of the word soliton, he was still active in the area and giving other people interesting ideas, so I deliberately went to Princeton to work with him.

My advisor was never scared to take apart a theorem. We would try and understand something together. And he would say, 'but this is the wrong way to do it'. And we'd go back right to the beginning and we would build it up from scratch again. I found this amazing, because nobody else I knew made that kind of effort to understand something so thoroughly.

*Gazette: Did you have a scholarship?*

*Joshi:* I had some kind of support, but they don't call it a scholarship [in the US]. You get teaching assistanceships or research assistanceships.

## **Working life**

*Gazette: What is the best career advice you have ever received?*

*Joshi:* I don't think I ever received any advice. Nobody ever said to me 'go into this direction' or 'move to that university'. I just followed my instincts. I'm a very stubborn person, and I don't let things get in my way.

*Gazette: Could you see yourself working in the industry?*

*Joshi:* I've never worked in the industry. I did look at it very seriously when I was at university. I looked at doing engineering of some kind. I really wasn't sure what I wanted to do at the end of uni: I looked up some aeronautical companies, I looked into modelling for a gasline company. I saw myself as happy if I could do some mathematics in some group, it didn't matter where that group was. But once I did honours, I just wanted to do a PhD.

*Gazette: When did you get married?*

*Joshi:* Half-way through my PhD. My husband was also doing a PhD at the time, in geophysical fluid dynamics. But he'd done applied maths in honours as well, so we went through this together. The only reason he was doing a PhD was because I was doing a PhD. We were very lucky that we could go to the same place.

*Gazette: You had your children early on in your career — your son while you were a postdoctoral researcher and your daughter a few years later when you were a lecturer at UNSW. What was your experience like of combining family and working life?*

*Joshi:* There were lots of problems. I deliberately wanted to breastfeed my children for a year after they were born, as they were both premature, and that was very very difficult because they went to childcare. I had to work and people just didn't think about those kinds of issues for staff members in those days. It was a difficult time. And I would say that probably workplaces weren't that friendly for child rearing, when they got sick you couldn't really take the time off. There was no parental leave in those days.

*Gazette: What impact did this have on your work?*

*Joshi:* Around the times when they were very young, it certainly had an impact. I also recall that at one stage I had to go to a conference. My husband and my son had moved to Adelaide and my daughter and I hadn't moved from Sydney yet because I was waiting for an opportunity in Adelaide. So I happened to mention in the tea room that I was looking for somebody to stay at home with my daughter so I could go to the conference, just for a week. One person told me that I was a bad mother because I would even contemplate going away and leaving my child with a family member. Those kind of things are hard. But I don't want to talk about all those hard things.

*Gazette: What positions have you held?*

*Joshi:* I came back to Australia [after my PhD] and moved around a bit. I stayed at ANU for about  $3\frac{1}{2}$  years. Then I was at UNSW for  $5\frac{1}{2}$  years. But my husband didn't have a permanent position. So in an effort to find a permanent position for him he moved to Adelaide to join the DSTO and I had to resign my job at UNSW to follow him because I couldn't get a situation where I could get leave without pay and possibly come back. So I went to Adelaide on an ARC Senior Research Fellowship for five years and then I got a Chair at the University of Sydney. Thankfully DSTO is very forward-looking as an organisation so they allowed my husband to work in Sydney even though he belongs to a group in Adelaide.

*Gazette:* You are a member of . . .

*Joshi:* The American and the Australian Mathematical Societies. I joined the American Mathematical Society when I was a graduate student and I'm still a member because it keeps me in touch.

*Gazette:* What about the Australian Academy of Sciences?

*Joshi:* I was elected as a Fellow in March 2008, for my overall career contribution. I'm only the third female mathematician to be elected: the first was Hannah Neumann and the second was Cheryl Praeger. In general, the ratio of females to males in the Academy is very small. I recently tried to find out how many female Fellows were from Sydney University. There seems to be only two currently including myself — that's a bit of a shame.

*Gazette:* Postgraduate students?

*Joshi:* I seem to attract postgraduate students. I somehow fall between two stools: a lot of students get very interested in doing problems that are motivated by physics, but in many physics departments there isn't a mathematical or theoretical specialisation. Students then look around and find people like me. These are usually students who are very good at mathematical calculations, who want to do deeper things, but are motivated by something in the natural world. I've had four PhD students complete their PhDs with me. The fact that I moved around has made that a little more difficult. I didn't have any PhD students in Adelaide. I currently have two PhD students, and may have one more next year. I love working with students — I find it incredibly satisfying. I love working with undergraduate students too.

When I was an ARC Senior Research Fellow, I didn't have to teach. I found that I really missed the teaching and the connection with students; the fact that you can explain things to them, and see the spark in their eyes.

## Looking back

*Gazette:* What achievement are you most proud of?

*Joshi:* One example I always use when I talk to school students is how I solved the Towers of Hanoi problem. This was a long time ago. I remember doing that calculation and realising that I could do it without looking it up in any books in the library or going and asking somebody for help. That was really revealing and very satisfying. That was my first problem . . . I wasn't that young, but I remember feeling as though this was something that built my confidence.

I'm very proud of the work I did as part of my PhD. Because it involved solving a set of equations I don't think there's ever been a methodology invented for. It was non-analytic, involved highly transcendental functions. I remember, one summer, I woke up at 1 am every night because I had to solve this problem. And I'd go away and fiddle and do calculations on a piece of paper. And then I'd do it again, and again, and again until finally I got an answer. My advisor hadn't expected the answer that I got.

*Gazette: Can you give advice to early career mathematicians?*

*Joshi:* Have confidence. Once you get there, you've come through as a mathematician. You've actually worked out something for yourself. You've solved a problem. And that means that you've got the ability to do more. So start with confidence! Don't be scared of developing your own point of view. In any field of Science there are hierarchies of accepted view points. There's a great deal of pressure to work within an acceptable hierarchy. That can be very stultifying. You've got to develop your own point of view and communicate this to others. And learn how to communicate it so you don't offside people.

The other thing I'd like to say is that it is important to tackle the harder problems. You have to publish, publish, publish if you want to go into an academic career. But you should also tackle the harder problems and not just fall into the trap of publishing just the easy results.

*Gazette: Women in maths — have all the problems been solved?*

*Joshi:* I think attitudes have changed. People are more open and generous nowadays. But as I said before, it's a case of benign negligence, people don't see that there are a lot of blind spots.

## Looking to the future

*Gazette: What direction would you like to see the AustMS go into?*

*Joshi:* I think it has to become a more strategically focused society. It has to allow itself to be more vocal and more visible in a national setting, rather than being introverted and only maintaining an annual meeting. It has to take the bull by the horns and become a lobbyist.

I guess we'll have to talk about that amongst ourselves. We've said for a long time that mathematics has been undervalued and treated badly on the funding scheme. We have to think about not just complaining, but finding solutions and proposing them to the government.

*Gazette: Who are your main collaborators?*

*Joshi:* For a long time, it was Martin Kruskal. One more recent one is Alexander Kitaev. He's a very good mathematician. We looked at the solutions of the first Painlevé equation — ordinary differential equations. This comes up quite often in places like random matrix theory. People had a qualitative idea about what the solutions did. There's this particular solution, called a tritronquée solution — nobody really knew where the first real pole of this solution was located. If you come in from infinity then it seems to be bounded on one half of the real line and then you encounter a pole. The solutions are highly transcendental. We were the first to provide a way of approximating the position of the pole to any order of accuracy, and to prove that the solution was pole free to the right.

I've worked with lots of other people. For example, Frank Nijhoff, at the University of Leeds. Every time we meet we talk about something that has elliptic

functions and hyperelliptic functions — we meander all over the place. We've written several papers together, and I'm sure there are many more to be written.

I work with people in Japan, and others in the UK, France, Finland.

*Gazette: Why do you do mathematics?*

*Joshi:* Because I discover new patterns.

*Gazette: Hobbies?*

*Joshi:* Oh dear. I don't have time to pursue my hobbies! I love doing a lot of different things. I read. I'd love to read more. I love going on walks.

*Gazette: So are you joining the walk this afternoon?*

*Joshi:* No, I'm not, actually. I'm doing the winery tour. I love wine tastings, and figuring out what is a good wine. I love doing things like knitting. I've decided that I love architecture. I love going to art galleries. Being exposed to different types of art. And I love travelling.

*Gazette: Thank you very much, Nalini!*

*Joshi:* Thank you.

