# Mathematics as a Positive Mental Place – An Interview with Gigliola Staffilani

Roberto Natalini (Consiglio Nazionale delle Ricerche, Rome, Italy, Chair of the Raising Public Awareness Committee of the EMS)

*Gigliola Staffilani is an Italian mathematician working in the USA as the Abby Rockefeller Mauze Professor of Mathematics at the Massachusetts Institute of Technology. Her research concerns harmonic analysis and partial differential equations. In 2014, she was elected to the American Academy of Arts and Sciences.*

***Roberto: Gigliola, could you describe your background, your early education and your life as a child in Italy?***
Gigliola: I was born in a small town in Abruzzo. My parents were farmers and I lived with my family and that of my dad's brother. I really enjoyed playing outdoors with my dear friend Lina, who lived next door.

I was very good in school, in particular math. I was also very competitive and I was very unhappy if I did not get the highest marks. My brother is 10 years older than me and he was the first in the family to go to high school and then university. There were no books at home but he subscribed to "Le Scienze" and so, from very early on, I started reading about amazing discoveries in science. I couldn't understand much of what I was reading but I loved the short biographies of the scientists. It was during this time that I learned about Princeton, Stanford, Harvard, MIT… I loved my childhood but unfortunately, when I was 9, my father, who was 43, got sick with advanced colon cancer and died in less than a year. I was devastated and I lost my carefree spirit. In order not to think about my loss during my spare time I decided to start solving math problems from my school book and I continued doing it well into high school (and somehow this worked).

***What did you think about mathematics when you were a child?***
I loved the fact that mathematics was completely logic – no surprises there. I liked the fact that I could control it and that a proof was not subjective or emotional. I had enough negative emotions around me and I just needed a mental place where no emotions were taking over everything.

**Gigliola Staffilani – image from the video "Truth Values: One Girl's Romp Through M.I.T.'s Male Math Maze", as part of the institute's 150th anniversary celebration, December 2012.**

***Could you describe the beginning of your career in mathematics in the United States? Was it hard to start as an emigrant in a new and unknown country?***
I think that the first and probably biggest "culture shock" came when I moved from my little town to Bologna. The move from Bologna to the University of Chicago was in a way simpler, in spite of the fact that I encountered

an endless lists of obstacles. I didn't have to prove anything to anybody in Chicago and I was completely naive about American culture. The first obstacle I encountered once I arrived on campus was that I couldn't register as a student because I had not taken the TOEFL exam. In fact, I didn't know any English. As a consequence, I only had a "prospective student visa" – not enough to register. Since I couldn't register, I couldn't live as a student in the International House, so I found myself basically homeless in one of the most dangerous campuses in the US. I decided to look for a room to rent as I had saved some money working during the previous two Summers. I found one unfurnished and I took it; at least I had a roof over my head. Fortunately, though, the chair of the math department allowed me to register as a student in spite of the visa; he was just hoping that I would give up after a couple of weeks and solve the problem. But I stayed for a whole month. Then, a second obstacle appeared. I didn't receive the first cheque of my fellowship. I learned later that this was again a consequence of the fact that officially I was a "prospective student". At this point, I was ready to give up and, with enormous disappointment, I decided to use the public phone in the math department to make a reservation to fly back to Italy. While at the phone, my registration advisor, Professor Sally, walked by. He noticed that I was upset and he signalled to me to end the phone call and talked to me. With my broken English, I explained the situation and with total ease he walked me to his office and gave me a personal cheque of about $1,500, which was the equivalent of my first month of fellowship. Very often, I think about this event: a completely random and lucky coincidence that may not have happened at all. If so, my life would have been completely different!

***You are now a worldwide recognised expert in harmonic analysis and dispersive partial differential equations. How did it happen that you started to work in this area? Why do you like it?***

I started working on harmonic analysis as a student in Bologna when I was writing my thesis on certain Green's functions. I like analysis; for me, it is way more flexible than algebra. Harmonic analysis, in particular, allows you to reduce many problems to understanding a variety of interactions between simple functions and then reassemble them in a clever way to deduce properties for general functions. I think it is a very powerful and flexible tool.

**Gigliola Staffilani during a workshop at the Institut des Hautes Études Scientifiques, Paris, July 2016.**

***Could you explain, for an educated but not specialist audience, the core of these works about dispersive equations you performed in the first part of your academic career?***

When I started talking to my advisor at the University of Chicago, Carlos Kenig, he explained to me that I could work in one of two areas that he was an expert in: elliptic equations, on which incredible progress had been made in the preceding years and where the problems left open were really hard, or dispersive equations, on which he had started working more recently and where many problems were completely open. He added that he didn't really know if this direction would become central in analysis. I decided to take the second option and I am glad I did because, indeed, thanks also to the work in this area by Jean Bourgain and Terence Tao, dispersive equations became very important. The main questions that I addressed with collaborators were on existence, uniqueness and stability (well-posedness) of rough solutions to dispersive equations, such as the Schrödinger of the KdV equations. We were interested in rough solutions because one would like to assume that only the mass ($L^2$ norm) or the energy (related to the $H^1$ norm) are bounded for these solutions. As a first step, one would prove well-posedness in a small interval of time but the next and harder step is to understand what happens when time evolves arbitrarily far. To answer this question, with my collaborators Colliander, Keel, Takaoka and T. Tao, we invented the concept of "almost conservation laws", which was then developed in many different contexts by us and other researchers.

***What are the main contributions you have made in your field – the main original ideas?***

I would say that the idea of the "almost conservation laws" is what I like the most.

***Could you mention the most important of your mathematical results and why it is important to you?***

For me, the proof of global well-posedness for the energy critical nonlinear Schrödinger equation in 3D is my most important result. I think it is important because we had to find a missing ingredient, now known as the interaction Morawetz inequality, which is actually a fundamental identity that had not been discovered till then.

***You collaborate with some other well-known mathematicians, such as James Colliander, Markus Keel, Hideo Takaoka and Terence Tao, and I read that you are known as the "I-team". Could you explain the meaning and the origin of this name?***

We are called the I-team because, in one of the original papers on "almost conservation laws", we used a multiplier operator that for no special reason we called "I". I guess we had run out of other good letters by that point.

***You were appointed as a professor of pure mathematics at MIT. I believe you are one of the few women to get this kind of position. What is your feeling about that? Is the situation changing?***

When I arrived at MIT, there was only another woman in applied mathematics; I was the only one in pure mathematics. Today we are a total of five. So, a little improvement but not much if one considers that there are a total of 53 professors in our department.

***How is the environment in your department and how is it important to you for your work?***
I love my department; it is very "democratic" and people listen. Of course, there are discussions but they are constructive. There are no groups fighting against each other and everybody is invested in having the best set-up for students, postdocs and professors that we can possibly have. This, for me, is absolutely fundamental. I need to feel happy when I go to my office; otherwise, I would be a terrible researcher, teacher and mentor.

***What about more recent problems you have considered? What is the core of your activity nowadays?***
Recently, I have been introducing a little more probability into my work. Often, when working with rough data, one can prove that there are special counterexamples for well-posedness. But, if one is a little less greedy, one may be happy to claim that for "almost all initial data", well-posedness is available. Of course, one has to make sense of the "almost all" but this is what probability is for. I have also been working on the integrability structure for a certain hierarchy of so-called dispersive equations that model Bose-Einstein condensation in the framework of Gross-Pitaevskii theory.

***You have been awarded many honours and prizes. Which one is the most important to you?***
I would say being elected to the American Academy of Arts and Sciences has been really great. It is such an historical organisation that I feel like I am part of history itself. Also, as a member, I get to discuss possible directions in education that may one day affect many people, so it is a bit like "giving back" to society.

***How much in your work is intuition and how much is just hard work?***
I think, in my case, it is 50%-50%. I believe that intuition comes when you have cleared up your brain to receive it. To clear up your brain, you need to work hard to eliminate all those attempts that do not lead anywhere.

***How do you organise your work? Do you follow a routine or does it vary a lot according to external conditions?***
Recently, I have been working a lot with senior collaborators and postdocs. It is difficult to juggle everything so I try to set aside certain times with certain groups that are essentially fixed every week. So, I would say that I follow a routine.

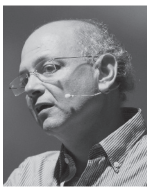
***According to you, what is the situation of women in mathematics around the world? Is there any difference between Europe and the United States?***
I can compare maybe Italy and the US. I think in both countries there are too few women at the level of full professor. But, in Italy, I do not think that people believe that the reason is that women do not have the same talent as men. Unfortunately, in the US, people still think that women are not good at math in general and that not being good at math for a girl is totally acceptable. This social belief is really difficult to change I am afraid.

**Gigliola Staffilani and her family, from the interview on the Italian site MaddMaths!, December 2010.**

***You are committed to reducing the gap between women and men in mathematics. What are your actions in this direction?***
I strongly believe in diversity, in all its shades: gender, race and family background. I believe that when there are no role models, it is very difficult to imagine yourself in a certain position, so I am a strong supporter of having role models as mentors. At MIT, I organise a lunch seminar, where I invite senior women mathematicians, working in academia or industry, to come and recount to the women in the department (from undergraduates onward) how they arrived to the place they are now. In doing so, they also explain, in general terms, the mathematics they use in their research or their job.

***What do you do outside math? Do you have hobbies?***
I really do not have much time for myself but when I do I like to go hiking, take care of my small city garden and, most of all, spend time chatting with my kids and my husband.

***How is your relation with Italy now? Are you still in touch with your country?***
I love to visit Italy, either for work or personal reasons. I am in touch with a few mathematicians there and I have lectured in a few Summer Schools as well. In July, in fact, I will be in Rome for a week!



*Roberto Natalini has been the Director of the Istituto per le Applicazioni del Calcolo "Mauro Picone" of the National Research Council of Italy since 2014. His research interests include fluid dynamics, road traffic, semiconductors, chemical damage of monuments and biomathematics. He is Chair of the Raising Awareness Committee of the European Mathematical Society.*