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Proof by example Portraits of women in Dutch mathematics

Elena Pulvirenti

Elena Pulvirenti is an Assistant Professor in the Applied Probability group at Delft University. Her main research interests are in mathematical statistical mechanics and probability.

What first got you interested in science?
"Since my school days, I have always been interested in scientific subjects, though as a kid, I had no real passion for mathematics. I think it was because I was very slow at computations — and to be honest, I still am very slow — and this always made me nervous. However, I did love geometry and afterwards, when I was in high school and numbers somehow were replaced by abstract concepts, I finally started to understand mathematics and realised it was a lot of fun.

At the same time, I was also fascinated by physics, by how it could explain phenomena around me, including those that I could not see, like currents or magnetic fields. So, when I had to choose what to study at university, I decided to go for physics, because I wanted to understand things better. In a sense, I was challenging myself."

How did you end up pursuing a PhD in mathematics?
"I studied physics in Rome la Sapienza, a choice that has been essential for my career path. During my Master's, I took a course in statistical mechanics. There, again, I was impressed and surprised by the possibility of explaining the macroscopic behaviour of thermodynamic systems from a probabilistic point of view. This fusion of physics and mathematics was so interesting, and it also gave me great satisfaction to see that starting from a mathematical model one could rigorously obtain some of the first principles of physics, like the second law of thermodynamics. This really surprised me and gave me the same feeling one gets after putting the last piece in a jigsaw puzzle. At that point, I understood that I wanted to be a mathematician because I needed to complement my knowledge in physics with the rigour of mathematics."

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Somewhat your research still has physical motivations. What projects are you currently working on?
"At the moment, I am focusing on interacting particle systems, both in the discrete and in the continuum. All of these systems exhibit *phase transitions* and *metastability*, which is somehow the dynamical counterpart of phase transition. Metastability is a widespread phenomenon occurring in the dynamics of systems that are subject to random noise, and I am very interested in understanding it."

Can you give us an example of metastability?
"Here is a simple experiment you can do at home. Put a bottle of distilled water in the freezer and then take it out after some time. Of course, you would expect the water to freeze and become solid. Instead, what you may see is that, even though its temperature is below zero, the water is still in a liquid phase. However, once you open the bottle and pour the water into a glass, then it freezes almost instantaneously.

This liquid state the water was in is called a metastable state. The system 'would like to be' in the solid phase, but for physical reasons, it stays in this metastable state for a long time.

Mathematically speaking, the liquid phase is not a stable state. The system will eventually reach the real stable state — which is the solid phase. One can think of the metastable state as a local minimum of the functional: somehow the system gets stuck there, but eventually, it will evolve into a stable state. This may take a very long time and typically one is interested not only in making sense of the phenomenon of metastability itself but also in estimating the average time it takes the system to do this cross-over to the stable state.”

What kind of systems exhibiting metastability are you currently working on?

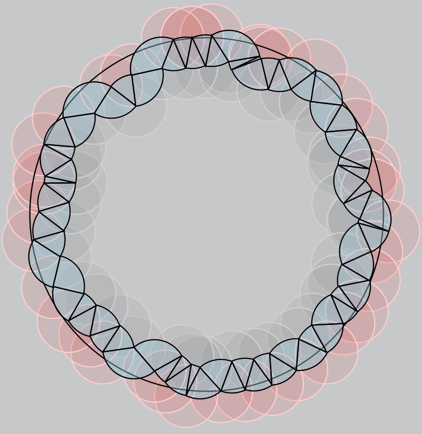
“Recently, I have been working on metastability for spin systems with ‘bond disorder’. In this case, we have two sources of randomness: one is the dynamics of the spin system, a spin-flip type of dynamics, and the second one is that the coupling between any pair of spins is random.

Again, what one would like to do is to estimate the average time that it takes for the system to go from a phase where the majority of the spins point down to a phase where the majority of the spins point up. The challenging part is that now the spins are interacting via random couplings. One of the reasons which make these random systems with bond disorder very appealing is their deep connection with the theory of random graphs, which lately have become very popular due to their application to real-world networks.”

Is there any results that you are particularly proud of?

“For many, many years, I have worked on a project concerning the study of metastability for a system in the continuum called the Widom–Rowlinson model. It is a model of fluid with a phase transition of the liquid-gas type.

Together with Frank den Hollander (Leiden), Sabine Jansen (Munich) and Roman Kotecký (Prague/Warwick), we obtained results that can be seen as a first step in understanding metastability. This involves a very sophisticated analysis of the so-called critical droplet of the system. The system, in this condensation process, creates a droplet of liquid in the gas space. We studied the fluctuations of the random boundary of this droplet. It is the first detailed analysis of the surface fluctuations down to both mesoscopic and microscopic precision. This result is also interesting because it provides a mathematical foundation for the theory of capillary waves. The idea of studying the fluctuation of the random boundary drop is the result I am most proud of, and the reason for that is that it was quite challenging to get to it: it required a lot of analysis and probability. In some sense, the things that I find difficult are the ones I like the most.”



Example of a two-dimensional critical droplet for the Widom–Rowlinson model in the metastable regime.

What do you like the most about being a mathematician?

“I like very much having the freedom of working on the projects I find most interesting. Of course, like everybody else I think, I like the rewarding feeling of having proved a theorem, which is priceless. I also like the interactions with my colleagues, the never-ending conversations, the exchange of ideas, and, of course, the conferences, when it was still possible.”

How has your experience with remote working been so far?

“From a certain point of view, working remotely during the pandemic turned out positively for me. I started many new collaborations with people that I had not seen in years, just because at some point we wrote to each other and started to talk about maths. The whole situation might be alienating, of course, but, as said, has also had some positive effect on my research, as I have started to work more with people that in the past I would have considered to live and work ‘too far away’.”

Is there anything you found difficult in your career as a mathematician?

“The answer is everything (laughs). One thing I have struggled with is the fact that sometimes one embarks on a very challenging and long term project which does not yield the expected results in a short time. This can be very challenging and frustrating, especially for someone at the beginning of their academic career. This is actually what happened with the results I am most proud of. Being stuck on a problem for a long time is of course difficult, but this is also the essence of being a mathematician.”

How do you experience being away from the place where you were born, and living in a different country?

“I like it living and working in the Netherlands: it is my second home! But, of course, I miss Rome, and I miss my family, and that did not get better during the pandemic. It has been a challenging time.”

Have you received any particular kind of support during your career that you are thankful for?

“I am lucky to have always been supported by every supervisor and collaborator, especially before becoming an assistant professor. But one thing that really made me feel supported happened while I was still living in Germany and I had a small baby. I wanted to go to a conference and I got financial support for paying the trip for my mother to come to help me during the event. Universities are trying to develop ways of supporting parents with child care responsibilities. Paying for someone trusted to come and take care of the child, as opposed to offering child-care, can make a huge difference. It is essential that one feels relaxed at a conference, and I found such initiatives a good way to support parents and allow them to make the best of the event they are attending. I would recommend to other mathematicians that have parenting responsibilities to explore all options and think outside the box: there may be something they are not aware of that could make a difference.”