AN INTERVIEW WITH

Sylvia Serfaty

by João P. Nunes*

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Sylvia Serfaty is currently Silver Professor of Mathematics at the Courant Institute of New York University. Since obtaining her PhD from Université Paris-Sud in 1999, she has embarked on a stellar mathematical career in the fields of analysis, partial differential equations and mathematical physics. She has received many distinctions which include, among others, the European Mathematical Society Prize (2004) and the Henri Poincaré Prize (2012). Since 2019, she is a member of the American Academy of Arts and Sciences.

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In the beginning of your career, why did you choose the field of PDE and Ginzburg-Landau models ? Did you hesitate between this and any other topic ?

It really happened by chance. I didn't know what to specialize in, I liked analysis but I also thought of differential geometry and dynamical systems. I decided to follow many different graduate courses, and along the way I ended up liking Fabrice Bethuel's course, which is how I did my PhD with him, and he proposed the topic of Ginzburg-Landau vortices.

Can you describe, in a few words, what are the main long-term goals of your research ?

After a long streak on Ginzburg-Landau, I am now mostly focusing on statistical mechanics models of particles with Coulomb interaction, similar to the vortex interactions but in general dimension, and also their dynamics. In the long term, I would like to understand better what happens in these systems: the phase transitions (such as the Kosterlitz-Thouless phase transition and the possibly solid/liquid phase transition in two dimensional one-component plasmas). But maybe it will be too hard and I will think of something else! A lot of research is not planned, but happens as you go along.

In recent work, you relate the Cohn-Kumar conjecture on energy minimizing configurations of points in dimensions 2, 8 and 24 to conjectures on systems with Coulomb interactions. What makes these dimensions special ?

The conjecture is only made for these dimensions. What is special about them is the existence of lattices which are such that the norms of all vectors in the lattice are the square root of an even number (I am simplifying a bit here). There could be other dimensions where the existence of such a lattice occurs, but for sure, it is not true in all dimensions. For instance in dimension 3, there is no such lattice, and the Cohn-Kumar conjecture (that there is a universally minimizing lattice) is wrong, as the optimal lattice depends on the precise nature of the monotone interaction.

Among the very many results that you have produced over the years, is there one that you consider to be mathematically the most beautiful ?

I would say there are two competitors: one is this work with Étienne Sandier you alluded to, where we bridge between the Ginzburg-Landau model of superconductivity and the Cohn-Kumar conjecture in dimension 2 — essentially we prove why the Abrikosov (triangular) lattice happens. It comes as the culmination of a long program with technical buildup and is striking both from the mathematical and physical point of view.

The other is the introduction of the modulated energy method for deriving the mean-field limit for Ginzburg-Landau dynamics with many vortices, and which ends up working for more general discrete dynamics. I think I particularly like it because I thought about it on and off for 17 years before finding the right approach, which in the end is quite simple to phrase and elegant, in my view.

When you moved from France to the US, back in 2001, what were the main differences that you found from the academic point of view ?

Everything is similar and everything is different at the same time. I think I was shocked that in the US you can get a whole undergraduate education in math without having seen a proof-based course except for the last two courses in the last year. At the same time, the situation of the faculty is much more comfortable than in France and even more valued in society. It seemed a really strange use of the intellectual power of the faculty to make them teach these undergraduate courses. I felt like I was being used as a high school teacher, academically and also emotionally. In office hours, US students told me about their life problems and expected me to hold their hand in their studies in a way that students in France never would. And the contrast with graduate courses was huge, much bigger than in Europe.

How often in your work have fully-blown theorems and results start by some particular, simple calculation or observation that you can identify ?

This has definitely happened several times, in fact most theorems start this way, with a little calculation. I remember particularly the time early on where I found an identity which provided an *entropy* and thus a lower bound (in a sort of calibration way) for the model of micromagnetics I was studying with Tristan Rivière. I remember I was very excited, it felt like I had stumbled upon it practically by accident. The modulated energy method and the Gamma-convergence of gradient flows were also in that category although the computation came more from a conceptual reasoning.

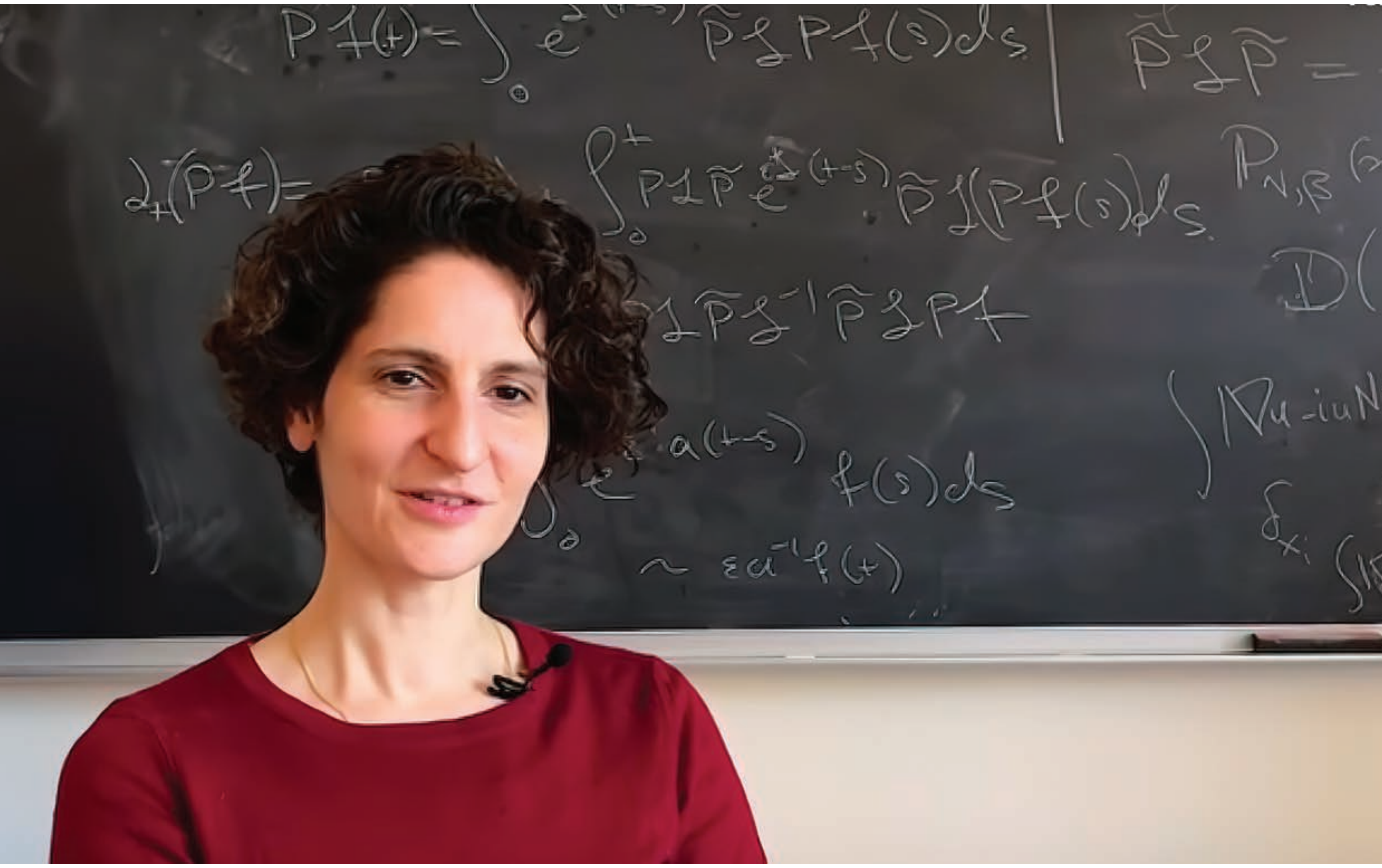
What kind of teaching do you do at Courant ? Both graduate and undergraduate ? How does teaching interact with research ?

Yes, I do both graduate and undergraduate. The graduate teaching very directly interacts with research, as most of my PhD students follow my courses, and also the students of other colleagues. The more advanced *special topics* courses are places of discussion with the students, I sometimes ask them to present papers that are recent research, and often research questions or progress happens in relation. In fact the interaction with the PhD students is, I would say, my favorite part of the job. I am quite proud of my students!

I have read that you play the piano. How often do you play, what role does music play in your life ?

It depends on the periods, often these days I don't play enough because I am too busy. I try to do it at least a couple of times a week. When I finally do it is always a moment to relax and let my thoughts wander. It is for me a way to connect to music, and an activity that is totally *free* in the sense that it is not serving to achieve any goal or duty, and we don't have many of these.

Do you play in the periods when you are more intensely involved in a hard point of a research problem? Does it help ?



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I haven't observed any correlation but I will pay more attention now!

You have mentioned that your interest in Mathematics arose in high school. Can you imagine yourself with another occupation? What would have come in second after Mathematics? Would you be also a researcher? In what field?

Good question. I never thought of anything else seriously and never had a real plan B! I don't think I would be a good researcher in other fields, I am sure I would be terrible at experiments, or at things geared in data or concrete life, honestly. I think if I wasn't a mathematician I would like to do rather something else creative or artistic, sometimes now with age I start to think of writing … But it is not clear I have enough talent for other things!

If you had to choose a little piece of elementary Mathematics that lies the closest to your heart, what would it be ? (Sorry, I know this is an unfair question.)

I remember that when I was a student I had an esthetic shock when first learning about Z/pZ and how one can answer arithmetic questions mod p. I also liked any kind of functional inequality. For instance Cauchy-Schwarz or Minkowski, or the elementary proof by Fourier of the isoperimetric inequality in 2D …

Thank you so much, Sylvia.