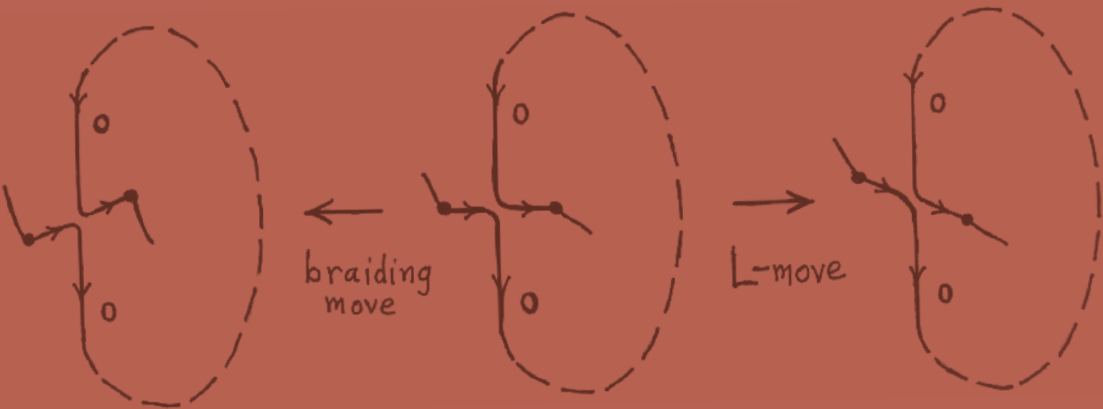
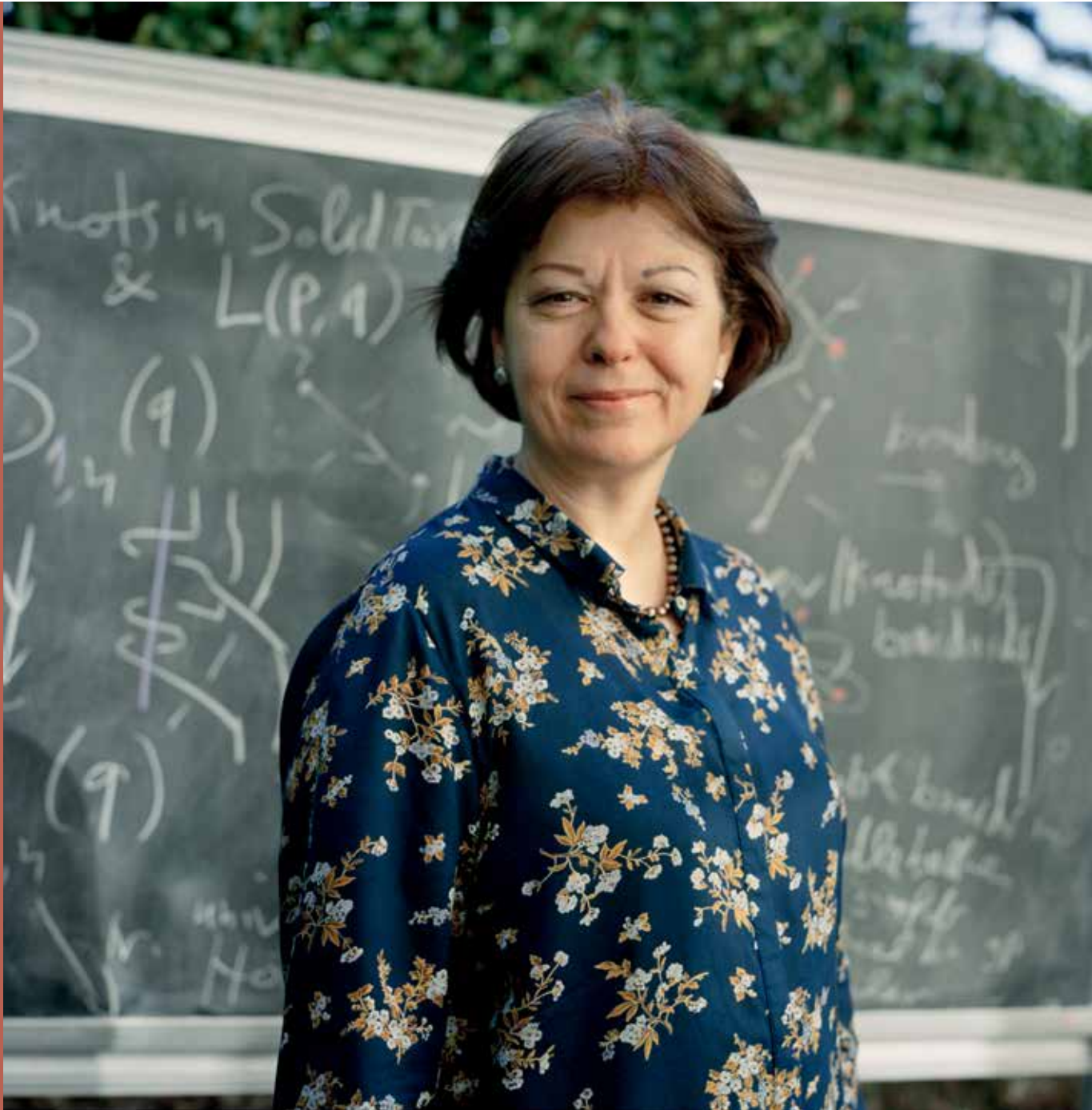


Sofia Lambropoulou



Sofia Lambropoulou grew up in the Olympia area on the Peloponnese peninsula and moved to Athens at age 9. She graduated in 1988 from the University of Athens with a B.Sc., did a Master of Science at the University of Warwick, UK in 1989, where she also got her PhD in 1993. She is currently Professor at the National Technical University of Athens, Greece.

- Research topics:
- Knot theory, low-dimensional topology
 - Construction of knot and link invariants
 - Knots and braids in 3-manifolds and in other settings
 - Applications of knots and knotoids to physics, chemistry and biology
 - Applications of topological surgery to natural processes



Geneva, Switzerland, 2019



How and when did you choose to do mathematics?

It was at quite an early age, when I was twelve. I had only just passed my maths exam at the end of the first term of high school, in one of the very good schools of Athens, called Marasleio, and so my parents sought help. They found a private institution that offered afternoon classes, owned

by an elderly man, Michalis Mantzaris, who had a deep passion for mathematics. He was hard-working, devoted and a man of principles, guided by ethos, austerity and mathematical rigor. He made a very deep impression on me, and mathematics soon became my strength. He turned me into his best student, and that is when I decided to pursue mathematics. I was fifteen when he re-

tired and it was only many years later that I learned that he had done a PhD in astronomy in Paris and written schoolbooks. It was thanks to him that I studied mathematics. Had I not met this professor, I would probably have studied other things I was interested in, such as architecture and cosmology. I was also very interested in psychology and in the philosophy of divinities. Yet, I think it was from

my father that I first started to learn mathematical thinking. From the age of five, he would explain practical mathematical problems to me, typically when walking together to the green-grocer's shop to get some food. He was a very loving and wise man, and a model employee of the Ministry for Economic Affairs. From him I learned to be practical, democratic and forgiving.

Were you then encouraged by your family, friends or other people around you?

My parents, particularly my mother, believed in solid education as a means for personal progress. Success was my mother's driving force, because she wanted me to become a professional woman. An exemplary schoolteacher and later a prize winner of several prestigious poetic competitions, my mother has an upright and reserved personality. From her I learned Greek grammar, a love of books and how to set myself aims.

Generally speaking, I was not prevented from aiming for a career in mathematics. However, when Dr. Mantzaris retired, I was disappointed not to find the help I needed. There was another regional private institution, but it wasn't nearly as good, so I chose to study on my own. At some point my parents, who were looking for help

for my elder brother, introduced me to an influential mathematician from my hometown, Pothitos Stavropoulos. After a short interview, he suggested an out-of-the-ordinary option for me. He had in mind a particular institution, which unfortunately was far from my home and involved a very long bus journey. So I had to give up on that. To have a talent is a blessing, but it has to be recognised, encouraged and cultivated. I remember one very good maths teacher in my school, Michalis Kaparakis, who perceived my inclination for mathematics. In the final classes of Lyceum, I needed help to prepare for the university entrance exam. Greece has always had a very tough university entrance exam, to the extent that occasionally there were cases of suicide. My parents never hesitated when it came to investing their savings in our education, and they soon found a good mathematician to give me private tutorials. I would discuss with him the solutions I had worked out for the exercises in the schoolbook, and he would provide me with more exercises. I remember him trying to discourage me from following mathematics. His daughter was already studying mathematics and I felt that he considered me an usurper of his family's privilege.

Did you come across obstacles in pursuing your career as a mathematician?

My biggest obstacle came from within. I never took the easy way and my path was neither continuous nor straight. In retrospect I feel that on several occasions I "looped the loop", hopefully lifted in space-time by gradual progress. Even though I always felt appreciated and joyful in the company of friends, I was afflicted by feelings of unfair treatment, as if something hidden was opposing me. On the other hand, I was driven by a deep passion for mathematics and for exploring my life, in search of the truth. In my path, chance played an important part, though not randomness.

I come from a middle-class family, from the Olympia area on the Peloponnese peninsula. I was nine when we moved to Athens, my first quantum leap. The provincial society I grew up in was severely male-dominated and brutal in some aspects. The cultural difference compared to Athens was big, a quantum leap. I spoke with a strong accent and was teased at school. Eventually I dropped the accent. Such things, along with a conservative upbringing and the sense that as a child "I was not listened to" and felt that "I was treated unjustly", made me feel self-conscious. I was

very shy, silent teenager, full of anger. I had no option other than to fight for myself. I was a top student and very motivated, so I managed to enter the University of Athens.

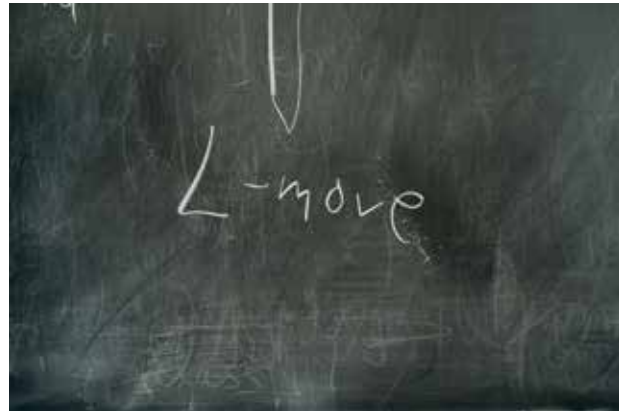
At the time, the situation in Greek universities was chaotic, a political turning point for Greece. Students and professors went on strike and many classes were cancelled. The situation was unpredictable and chaotic. Books were not available on time (by law, education is free in Greece and we receive a free book for each course). I found some books at the University Library, but they were written in very formal Greek. Many professors were active in politics or involved in power struggles, while others were indifferent. But there were also a few very good teachers. There was one teacher whose classes I remember were very exciting. Yet, as it turned out, this professor was totally obsessed with girls. After some discussions in the class he invited me to his office, asking me for my help with some translation from French to English. He offered me some liquor and tried to approach me, making me feel very uncomfortable. I declined his offer politely. A female co-student, who was also invited to his office and who had been asking me for help for the exam in his class, got a 10/10 whereas her ability level

actually corresponded to a 5/10. I only got 9/10, which seemed to me quite unfair. Such behavior of men towards women was built into the mentality not just in Greece. There was a lot of sexism rooted in society and a strong bias in favour of men, yet women were some 35% in my year. Retrospectively, given the open but also, and most importantly, the hidden and toxic incidents of sexism that I have been aware of so far, I have come to think that I was lucky that the professor who approached me was at least direct and not actually threatening. As a student, I started making lots of friends, some of whom I had deep discussions with on politics, books, social issues, philosophy and religion. One of my favourite Greek writers was Nikos Kazantzakis¹. I developed a free spirit with a strong urge to understand how things work. In my student times I felt the urge to rebel against the imposed role of the “good girl” which made me feel subordinate. I felt very miserable and remember wondering whether I was a “leper”, such was the discrimination I used to feel. But I was obedient, serious and thoughtful. In my effort to get my share of fun, I started going out more and picked up habits like smoking and drinking (which I later got rid of). I think I was seen as “the black sheep” of the family. I must

have given my parents a hard time. I was working, offering private tutorials to pupils while my older brother Haris was doing his PhD at the London School of Economics. One day he called me to encourage me to apply for one of ten positions advertised in some private bank, which meant taking a competitive written exam. “Why not try?” (instead of acting like a rebel), he asked. And so I did. It was extremely competitive (probably a success rate of 1 in 100) but I succeeded. I had decided to accept the job only if I was offered a position near my home, which happened. I still wanted to pursue postgraduate studies and the job enabled me to save some money for that. But practicing accountancy cost me a lot of time. It was when I got a position at the top technical university in Greece that Haris, by then an economist and university professor, showed clear signs of respect towards me. I eventually decided to resign from my job at the bank and started applying at English universities. A second quantum leap for me was going from Greece to England to do my post-graduate studies (1988–1993) when I was 25. Among the universities I had applied for, Warwick was the one I strongly wished to be admitted to, and indeed I was, after an interview with Caroline

Series. Even though I was a good student, I started my post-graduate studies with the feeling of missing fundamental mathematical concepts and of having to catch up. I vividly recall reading advanced maths books in my room with my eyes full of tears. The mathematics I was taught at the University of Athens were quite traditional, with a strong bias toward Analysis. I had insufficient background in Algebraic and Differential Topology or Bifurcation Theory. I nevertheless got a University Award for my MSc exams performance. I took classes from Ian Stewart, who accepted me as a PhD student, but then I gave it a second thought as my background in his research area was not strong enough. Excited by the recent outburst at the time in knot theory thanks to the discovery of the Jones polynomial, in the end I did my PhD under the supervision of Colin Rourke, thanks to a scholarship. I developed an idea for turning a knot into a braid, which was the starting point for later developments. Colin Rourke let me follow my inspiration and pursue my ideas, even though, as he warned me, he did not have the expertise to advise me further. At this point a close friend, the algebraist Meinolf Geck, taught me the basics on Hecke algebras.





In England I started talking and expressing myself a lot, to the extent that I was thinking and even dreaming in English. There I learned to be non-judgmental and to appreciate kindness, politeness and subtle humor. Also, I learnt that "it takes all sorts to make a world". It was there that I made up the motto that "in life there are *users and servers*". I met people who played a crucial role for my career, both positive and negative. When I was in my final year (1993), I attended a conference in St Andrews where Vaughan Jones was a giving a talk as plenary speaker. There, two years after our first brief encounter in Oxford, I found the opportunity to tell him about my work, which he seemed to appreciate.

In an antique shop in St Andrews, I found a wonderful platinum ring with a diamond in a geometric fitting, which I simply had to have. I paid a small amount to have it held for 6 months. Then I borrowed money from my brother and one day took the train. The purchase took place at the train station, as only 20 mins later I had to take the train back. I felt that this precious ring marked my engagement to mathematics.

In the following months I met Karen Uhlenbeck while serving tea during a conference, in the common room of the Mathe-

matics Institute of Warwick University, since the lady who usually did that job was on sick leave. Karen started talking to me and next day she offered me a MacArthur Fellowship for a five-week stay at the University of Texas at Austin, in consultation with Cameron Gordon given that his topics were closer to mine than hers. This gave me a push and it happened only a couple of months before I submitted my PhD thesis, which I defended successfully in front of Colin Rourke, Brian Sanderson and Hugh Morton. I had no concrete plan for after my PhD. I had heard from a German co-student about the Marie Curie EU post-doctoral fellowships, but could not imagine myself winning one. My mother encouraged me to apply and Vaughan Jones wrote a letter of recommendation for me, providing me with the "pass" to go to Cambridge for a 2-year post-doc. This was a real turning point for me. I had no teaching duties and travelled a lot to conferences and various institutes. In particular, one year later, so in 1994, Joan Birman, whom I had met at the Warwick conference, invited me to spend a month at Columbia University, NY. What proved to be another important milestone in my academic career was an unexpected invitation from Tammo tom Dieck to visit Göttingen

University, due to the work I had achieved in Cambridge. This invitation served for me as a confirmation that I had a place in mathematics. At the time Tammo tom Dieck was interested in similar things as I was (he wanted to construct Markov traces on Temperley-Lieb algebras of type B) and Gregor Masbaum had told him about my work. I visited him for successive periods of 2 weeks, 7 weeks and then 4 months. He eventually suggested that I apply in Göttingen for a C1 position (28 applicants, if I remember well) and I settled there for 4 years (1996–2000). In Germany I appreciated that people were well-organised, hard-working, serious, direct and outgoing, and had books in their living-rooms. I made unforgettable friends. In Göttingen, I hesitated whether to quit mathematics and start afresh by studying psychology, but I postponed my decision until after I had organised a conference as I had promised I would. It was a Knot Theory conference which David Yetter had suggested to have in Greece, during a meeting in Siegen. I therefore organised, almost single-handedly, and mostly from Germany, Knots in Hellas 1998 at the European Cultural Centre of Delphi. We had many big names and this conference is now a landmark in the history of Knot theory.

Recently, Knots in Hellas 2016 took place at the International Olympic Academy, building on the legacy of the first one. A participant wrote: "It is surprising that we can have a better conference, better than the best one in 1998."

At the end of the conference in Delphi, I drove Louis Kauffman, the author of the book "Knots and Physics", to the airport, and due to flight delays we spent three hours sitting on the airport floor. During this time he explained to me the applications of Knot theory to DNA. The topic was exciting and we agreed to work together. We have produced some 23 joint papers so far; some of them on the basis of discussions in airports, bearing "itineraries" in place of acknowledgments. We have spent several Research In Pairs² at the Mathematisches Forschungsinstitut Oberwolfach³ (MFO) and we figure in the Institute's advertising leaflet. Lou Kauffman has had and still has a big influence on me. He is unique: a great mathematician, researcher and teacher. I told him right from the start about my scientific background and my difficulties so that we could build a trustworthy relationship, and we have developed a deep friendship. From Lou Kauffman I learned to be open to new ideas, patient and persistent in research, tolerant and cooperative.

After 11 years away from home I was feeling nostalgic. It was when I went to a German-spoken opera that I decided I could not stay in Germany any longer. An associate professor position opened up at the National Technical University of Athens (NTUA), and luckily I succeeded, once more with the recommendation of Vaughan Jones. Settling back in Greece (where I have now been since 2000), finding my place there again and building my life turned out to be a very tough challenge. Yet I managed and I was able to reconnect with my roots and with the people I valued. I had my children and I am thankful to life for that. I could not view myself without children. I had an image of myself as a teenager, exploring nature with a child on my shoulders. I am considered a good mother and a good educator. From my children's Tae Kwon Do training I learned the motto: "Respect all, fear no one". I view myself as thoughtful, positive, liberal and progressive. Establishing my career in Greece was not easy. The situation in universities is still significantly behind that of comparable institutions in Europe, on a financial, administrative, organisational and political level. The financial means are very limited (not to mention salaries) and tasks that elsewhere would be straightforward require a lot

of time, energy and enormous bureaucracy. All these were and are serious obstacles in one's career. Luckily I have very good colleagues and I feel appreciated by my students, who are generally enthusiastic and have good abilities in maths. It is a pleasure to teach them mathematics, though it is tiring with large audiences. My research area is uncommon here in Greece, so for a long while I felt totally isolated. I introduced Algebra into my School's curriculum and I had to start training Diploma, MSc and PhD students from scratch, so as to slowly build up a research group. Another crucial milestone marked my career and for which I am grateful. From the 6 grants that I have handled so far as scientific coordinator, the most important one has been the research project THALES *Algebraic Modeling of Topological and Computational Structures and Applications* (2012–2015), which involved 56 researchers worldwide and for which Louis Kauffman was the Visiting Researcher. The THALES call was very competitive. My proposal was ranked in the top 5% of all proposals and was implemented with high excellence according to the grant-contributing authority. Heavy bureaucracy was involved, yet many young researchers profited and produced great results, while our research group became

stronger and well-known. Our results were published in a Springer PROMS volume. See www.math.ntua.gr/~sofia/ThalisSite/. Finally, a big component of my life lies outside mathematics. I don't like to focus on one thing and forget the rest, without giving to life what I ought to. I never acted as "blind" and "deaf" to people asking me for help, and numerous times I went out of my way to help people in difficult situations. In all these endeavours, mathematics helped me feel stronger.

In retrospect, are you happy to have chosen mathematics or do you have some regrets?

What are for you the joys of mathematics? What are for you the hardships of mathematics?

I certainly am! Mathematics sharpens the mind; it trains logical, methodical thinking and common sense, and helps in fast decision making. Mathematics trains one into stand for and prove what one claims. Yet the fact that it is absolute is the main strength of mathematics. It is not "either or", and the deep pleasure you get from a proof is that the proof will hold forever.

I also appreciate the power of prediction in mathematics. One can construct models simulating real-life problems and, by solving them, one can predict



how a phenomenon will behave at any given time.

Finally, the elegant beauty underlying mathematics is another important feature I like. It is a way for me to view the world. The beauty of mathematics is what I like to demonstrate when I teach, explain and do mathematics. I avoid technicalities if I can and present notions and theorems in a colorful and lively manner. Mathematics is deeply interwoven with my life and personality. I often use mathematical concepts to picture and explain life: asymptotics as an attempt to reach divinity, inter-squeezing balls for coexistence, the viewing of the 3-sphere as the union of two 3-balls to explain our internal world and the outside of us, etc ...

I like to think with my heart and feel with my mind, this is the motto of my mathematical path. I am rational in a friendly and human manner, not cold and dry. I believe that the motto "Mathematics in life and life in mathematics" describes me well.

I didn't plan my career as one might expect of a professional mathematician; it came about from my passion for mathematics and my intuition. Given these and the means I had at the time, I can't think of any professional career other than a mathematical career that I would have liked to pursue.

This choice did come with hardships though. Mathematics is a difficult subject per se and every mathematical area is like a different foreign language. When I left Greece to go to England I had a huge academic shock and it took me a long time to recover from that traumatic experience. Doing mathematics also means less socializing and more solitude and self-discipline. I recall countless nights in Germany working until very late on my research. Also, I often had to fund my own research to cover my own expenses for attending meetings, conferences and research visits, or to buy necessary electronic equipment.

What would you recommend a young woman in your country wanting to start a career in mathematics?

I would recommend to “go for it” only if one feels a passion for the topic, since mathematics is tough. It can bring phases of discouragement so one should be very dedicated and have chosen mathematics consciously. Then you should follow your heart and work hard. Whatever your background, if you want to, you can make it. I also recommended choosing an advisor with whom you feel you would like to work, for there is a human component involved in supervision. My recommendation, no matter

how hard the subject looks, is to go for it if it attracts you. You then have more chances of succeeding and producing interesting results. Here is what I would like to tell her: Defend your work, your words and your ideas / Be self-critical with humor / Face difficulties upright with seriousness and courage / Always be respectful, never subordinate / Exercise constantly and everywhere your free will and free choice / Follow your heart and your flair with perseverance / In maths as well as in life always be sceptical / Do not expect much financial reward and be ready to partly fund your own research / Standing for women is sometimes a matter of solidarity / You can combine having a career and a family – and it is worth doing so / Be generous and understanding towards younger people and teach them by example to search for the truth, whether scientific or not, and to respect the academic ethos / Life is earned through good and honest striving. For me, the aim is to be able to say in the end that “I added a small stone to the edifice of progress in mathematics and science”.

Could you describe your favourite personal achievements in mathematics?

My first achievement was a new algorithm I found during my PhD in Warwick, which turns

any oriented knot or link into a braid (Alexander theorem). V.F.R. Jones’ construction of his eponymous polynomial in 1984 prompted many mathematicians to revisit the Alexander and Markov theorems and also triggered the discovery of other knot algebras. The Markov theorem states an algebraic braid equivalence that reflects knot isotopy. The originality of my braiding algorithm lies in the fact that it is intrinsically related to a fundamental geometric move between braids, the L-move (as named by my advisor). From the different approaches to these theorems, each with its own advantages, the L-move led to a one-move analogue of the Markov theorem. Even more importantly, the L-move served to reformulate and prove braid equivalence theorems in many other diagrammatic settings, without the need for algebraic structures for the corresponding braids; namely for knots in closed, connected, oriented (c.c.o.) 3-manifolds and in handlebodies; for virtual, welded and singular knots; and more recently for knotoids and long knots. I am now recognised as an expert on this subject and an indication of this is that I was invited by the editors of the “Concise Encyclopedia of Knot Theory” to contribute a relevant article.



A second early achievement was that I succeeded in answering in the positive a question posed by V.F.R. Jones, namely whether there are other constructions analogous to the HOMFLYPT polynomial, a generalisation of the Jones polynomial to two variables, involving other types of Hecke algebras. I first connected the Hecke algebras of type B with the knot theory of the solid torus and of the lens spaces. Jones had mentioned other mathematicians to me, such as Vladimir

Turaev, Jim Hoste, and Josef Przytycki, who were looking in the same direction, but using diagrammatic methods. Another mathematician, Xiao Song Lin, had seen the link between the Hecke algebra of type B and the knot theory of the solid torus but had not succeeded in constructing a Markov trace. I had the topological intuition to find a finite set of rules for the Markov trace. This and several later results (including works with Meinolf Geck, Reinhard Haäring and my ex-student

Ioannis Diamantis) opened the way to the braid-theoretic approach to studying skein modules of 3-manifolds. The problem for c.c.o. 3-manifolds is highly complex, due to the handle-sliding move. The use of braids provides a more controlled framework and points at a unifying algebraic scheme for studying knot theories of 3-manifolds. From my later achievements I should mention first the combinatorial classification of rational knots and rational



tangles (instead of using the classification of the lens spaces) which I achieved with Louis Kauffman. Our motivation was that the theory of rational knots was used in the study of DNA recombination. Then, there is my work on p -adic framed braids with my long-term collaborator from Chile, Jesus Juyumaya, which opened up a new research direction, that of framework of algebras. It also

led us, together with Maria Chlouveraki and my ex-student Konstantinos Karvounis, to the discovery of a new skein link invariant which attracted the vivid interest of Ray Lickorish and Lou Kauffman, among others. In addition what I think I am particularly proud of is to have led excellent students who otherwise might not have had the academic achievements or careers they now have. I feel

deeply moved knowing that I have inspired quite a few people into pursuing mathematics and science. One of these students was Nikos Charitonidis, who later worked in elementary particle physics. He completed his PhD at CERN 3 years ago and is still working there. I was completely taken by surprise when I received a copy of his thesis bearing a dedication to me in

print: "For lighting up and holding the candle of my knowledge throughout the gloomy way – For teaching me who I want to be. Thank you." He and other "untypical" such students I advised (including Ioannis Diamantis, Eleni Panagiotou, Dimos Gkountaroulis, Stathis Antoniou and my student from Turkey, Neslihan Güğümcü) undoubtedly had a lot of potential. But perhaps because they did not have the traditional profile of an excellent student, they might not have managed to find their path in the competitive world of mathematics by themselves. I dedicated a lot of time and energy to helping them find it. They believed in themselves and strived to bring out their best because they trusted me and listened to my advice. Consequently, in my recent achievements I include my involvement in the topological study of polymer melts with my students Eleni Panagiotou and Ken Millett, which also led me to realise the great potential for applications of Turaev's novel theory of knotoids. So my student Neslihan Güğümcü worked with Louis Kauffman on knotoids, while together we developed the theory of braidoids. Then, my ex-student Dimos Gkountaroulis, with Andrzej Stasiak and collaborators in Lausanne, applied the theory successfully to the study of pro-

teins. Finally, with my student Stathis Antoniou we exploited an early idea of mine, namely to model via topological surgery and a generalized Lotka-Volterra dynamical system the topological changes observed in many natural processes, such as the behavior of whirlpools and tornados. We developed an enhanced model for topological surgery which gained the attention of many scientists. Recently, together with Louis Kauffman, we worked on connecting our model to the formation of black holes and wormholes in general relativity.

Could you describe your field of research to a non-expert?

Knot theory is a core area of topology that interacts in significant ways with many facets of topology, as well as with many other fields of mathematics and even with other life and physical sciences. The occurrence of knotting and linking appears only in 3-dimensional space, so classical knot theory concerns the classification of embeddings of a circle or of a collection of circles into 3-dimensional space. This is a classical topological problem, one of the big and still open problems in mathematics, which can be traced back to Lord Kelvin and C. F. Gauss. One constructs knot invariants, such as the Jones polynomial for example, which help distinguish pairs of knots.

Knotting is present in many natural phenomena, such as DNA, polymer entanglement and certain proteins for example, so topological methods of knot theory can be applied to study such phenomena. A basic notion of low-dimensional topology is that of surgery, which is used to change a manifold into another one. Topological changes can be seen in many natural processes such as the behavior of whirlpools in a pool of water (Falaco solitons) or the behavior of tornados and hurricanes; the changes of the embryo under cell division and also the change and evolution of shapes in natural forms. Hence topological techniques can be applied, in principle, to the study of phenomena exhibiting surgery. Finally, surgery along knots and links is related to the construction of c.c.o. 3-manifolds, whose classification in turn is related to the famous Poincaré Conjecture.

1 Nikos Kazantzakis (1883–1957) was a notable Greek writer, both a novelist and an author of essays.

2 Research in Pairs is a programme for bringing together small groups of researchers to carry out joint research in a research institute.

3 The Mathematisches Forschungsinstitut Oberwolfach (MFO, Oberwolfach Research Institute for Mathematics) is an international research centre situated in the German Black Forest.