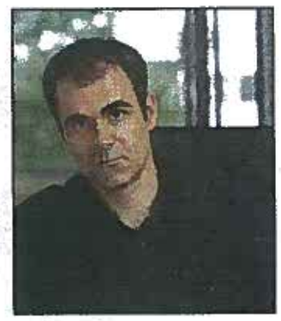
Adrian Constantin talks about water waves, tsunamis, and mathematics



With his book on the subject just published, the SIAM author and prize-winning professor discusses his career and interest in the mathematical aspects of water waves and also gives advice for those just starting work in the field.

Who or what got you interested in becoming a mathematician?

My interest was influenced and nurtured by a family that highly valued education, both parents being professors of mathematics. In adolescence I discovered that I was good at solving mathematical problems and enjoyed it. I had some success in mathematical contests. The alternating setbacks and rebounds in these competitions taught me a valuable lesson: Skills are important, but attitude is even more so. Talent is necessary, but hard work and persistence are also essential. And the enjoyment one derives from the activity should justify the effort.

I initially wanted to be a mathematician due to the satisfaction of excelling in a hard subject. I continued to do mathematics because, motivated by curiosity and desire for understanding, I developed sufficient sensitivity to replace this view with an interest in finding aspects of mathematics that are aesthetically pleasing. I also benefited from special circumstances: As a PhD student at the Courant Institute in the early 1990s I profited immeasurably from courses and seminars by some of the leading analysts worldwide. My advisor, Prof. H. P. McKean, had a knowledge of mathematics that was as broad as his understanding of it was deep. He taught me that while analysis could be regarded as an entity unto itself, it's more gratifying when it is inextricably interwoven with other branches of mathematics. Also that it is better not to be lured to the latest fad, that simple examples are stepping stones, and that mistakes are common when facing something new.

At later stages of my career, I had the good fortune to meet outstanding mathematicians who had an admirable code of conduct and true generosity, for example, Prof. L. V. Hörmander. Chance encounters of this type and information gathered by reading interviews with and biographies of other great mathematicians shaped my comprehension of mathematics and its role. In particular, the effectiveness of mathematics in understanding nature is striking. I believe that mathematical beauty is essential to explain phenomena and unravel mysteries of our physical word. Every small step counts, and I enjoy being involved in this endeavor.

Why did you choose water waves and tsunamis as a field of research?

Water waves frighten and thrill us for many reasons. They come in a seemingly endless array of forms, shaped by ever-changing influences, and yet they are to some extent mathematically predictable.

Despite remarkable developments over the last decades, we still have a poor understanding of many important aspects of water-wave propagation, for example, wave-current interactions and tsunamis. I find this field of research especially attractive since it draws freely from other disciplines but one can't use mathematical tools mechanically. Advances were obtained by blending asymptotic and numerical analysis, guided by physical intuition and experimental data. Mathematical rigor is also essential: Not only does it ensure the firm foundation and logical coherence of the theory, but often it also reveals facets that were not apparent in a more casual treatment.

The tsunami of March 11, 2011, turned the world's attention to these phenomena again. What new findings have resulted from your study of this tsunami?

Chapter 7 is devoted to some aspects of the propagation of tsunamis in the open sea. In this context I discuss the three largest tsunamis for which records are available (May 1960, December 2004, and March 2011). Of these three case studies, the presented approach is well suited for the first two, with the predictions of the theoretical considerations validated by field data. For the March 2011 tsunami a much more complicated approach has to be implemented. The relevance of detailed bottom topography suggests that a general approach is not advisable: The wave dynamics should be analyzed separately in each particular region.

What open questions in water-wave research do you find most compelling?

Despite its ubiquity, the wave breaking phenomenon is poorly understood. The potential generation of traveling water waves with overhanging profiles as a result of peculiar wave-current interactions is also very compelling.

What advice would you give to a PhD student or young researcher who is considering the study of water waves or beginning a career in this field?

For a PhD student the choice of the thesis advisor is the most important decision. However, a student should not reduce the quest for a PhD advisor to looking for the most eminent academic. He or she should also look at the styles of potential advisors, how they treat their advisees, and their track records in graduating students.

A young researcher should choose that type of research problem that he or she finds exciting or attractive but that is also in an area where the researcher is at ease. (In the study of water waves this could be analysis, computation, modeling, or any combination thereof.) Working on a research problem is not a state of bliss because the real interest begins when the unknown reigns, with occasional bright moments when the researcher makes progress.

Mathematics is not a spectator sport. To gain expertise necessitates learning proper techniques, and this requires disciplined effort and tenacity for the sake of a worthwhile end. Perseverance is important, and success is contingent upon the capacity of learning from failures. Since a mathematician will be exposed to more information than the mind can absorb, qualitative filtering is essential to withstand the quantitative bombardment.

As for research, incremental progress is important and depends to a large extent on one's technical skills and keeping up with the state-of-the-art. However, if the complexity of the technicalities is disproportionate to the status of the results achieved, it may be worth pursuing another elaboration of the research theme.

Finally, breakthroughs are rare and, being dependent upon creative leaps of imagination, the search for recipes is futile. Nevertheless, one can make a valuable contribution by mastering the basic principles and trying to adapt to a new context some already existing ingenious idea or framework. Likely sources of inspiration are the seminal contributions that have supplied the foundation for future developments in the field. Many ideas therein are likely to have been unexplored to their full potential due to a lack of adequate techniques.

Adrian Constantin is Professor of Mathematics at the University of Vienna and holds the Chair in Analysis at King's College London. His research interests include partial differential equations and dynamical systems, and he has made several significant contributions to the rigorous theory of water waves. His numerous awards include prizes from the Scuola Normale Superiore di Pisa in Italy, the Royal Swedish Academy of Sciences, the Humboldt Foundation in Germany, and the Japan Society of Fluid Mechanics.