

## ON MY ADVENTURES WITH STOCHASTIC MECHANICS

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When we pass 70 years of our life, even though we do not think that it is something extraordinary, some retrospective thoughts naturally come to our mind. They are stimulated by a simple observation that things around have changed tremendously in comparison with our experiences fifty or even twenty years ago. As the professional aspect is concerned, one has to realize that the formal employment is, in fact, over. So, one has to accustom to another role in the society – symbolized by a new “title”: emeritus. At this new stage of life it is not very likely that someone will encourage you to new challenges since the youngsters are believed to have greater capability. One should look for other, and perhaps – easier things to do. No doubt that reflections on the past are easier.

In the story below I wish to tell a reader – how it happened that I joined my life with stochastics, and more specifically – with stochastic mechanics. I also wish to mention some “events” on my professional road which made my life interesting.

When in 1960 I graduated from the Department of Mathematics & Physics of the Warsaw University (with the masters degree in mathematics) I got a job in the research institute for energy supply (Instytut Energetyki) in Warsaw. However, after few months I felt that this place did not give me sufficient satisfaction, so I kept my eyes open to find another place for my professional development. Once in the spring 1961 one of my colleagues from the University phoned me and said that the Institute of Fundamental Technological Research of the Polish Academy of Sciences (particularly: Prof. S. Kaliski working in dynamic elasticity theory and related fields) was interested in fresh graduates (with master’s degree) for doctoral studies. This message delighted me. After few months (since July 1, 1961) I had become a graduate for Ph.D. in the Institute named above (in which I have been working up to now).

In the first few months within my doctoral study my duty was to study mechanics, some branches of physics, theory of wave propagation and some other topics. One day (probably about the spring 1962) Professor S. Kaliski in short conversation with me (he was a busy and rather a formal man) said something like that: “it is a proper time you started to work on a specific problem which may lead you to Ph.D. degree; in this Institute nobody works in stochastic applications, but this is an important and promising topic”. And then he continued “the problem I have for you is the following: imagine that you have an elastic wave incident at randomly rough surface which separates two different elastic half-spaces. Since the surface is randomly rough the wave will scatter and the scattered wave field will be random. So your task is to solve the problem of scattering of elastic wave at random surface. Later you may also think on the scattering of the Rayleigh surface waves at randomly rough boundary of an elastic half-space”.

As I can recollect today, it was probably the most stressful conversation in my life and ... a perspective for a very hard time through all coming weeks and months (!). Even the simplest questions which I asked myself in the first weeks and months (in 1962) after this "conversation" were terrible. For example: what does it mean "random surface" ? How can one understand randomness of a scattered wave field? In the language of mathematics I have a random/stochastic boundary value problem for the elasticity theory equations – how can one formulate properly such a problem? In addition, there was nobody around with whom I could discuss my questions and ... share my frustrations. However, there is no doubt that the problem posed by Prof. Kaliski was not only challenging but also intriguing, attractive and important for applications.

This was the beginning of my way to stochastic mechanics!

A reader of this story can easily imagine that my work on the doctoral problem required much effort. It was also a time of continuous studying the analogous problems occurring in radiophysics, geophysics, acoustics. Searching for analogies has always been a power of science. In the middle of 1965 my doctoral thesis was nearly completed and its public defence took place in May 1966. This was a great relief; especially that at the same time (August 1965) I met Anna who one year later became my wife. So, my life entered a new, exciting and happy stage lasting until today.

The work on doctoral thesis introduced me into a wider circle of problems, namely – stochastic wave propagation which has become my field of research during quite a long time (until early 1980-ties). I extended my interest to the problems of wave propagation in random media. Such problems are mathematically modelled by the partial differential equations with random coefficients, or – treated in a different way when the wave transmitting medium is a composition of a matrix medium and randomly distributed inclusions (this topic was a subject of my habilitation in 1974; main results were published in *Acta Mechanica*, 1976). An important "event" in my life associated with stochastic waves was my research fellowship to the USA in the academic year 1970/71, especially, my stay in the Courant Institute of Mathematical Sciences of New York University. It was really exciting and challenging to live in New York city and be a fellow of this excellent mathematical institute with many famous names including Courant himself, K. Friedrichs, P. Lax and J.B. Keller who in sixties published the best papers on wave propagation in random media.

About the end of seventies/beginning of eighties (of XX-th century) I had noticed that the stochastic wave propagation is not the only field of my scientific interest. Also, I felt that perhaps, I should turn my research more to the main stream of research in the Institute (which was mechanics of materials and structures). It happened that I already was somehow prepared to such a change. The academic year 1975/76 I spent, as a Talbot-Crosbie research fellow, in the Department of Mechanical Engineering of Glasgow University working with Professor J.D. Robson and Dr D.B. Macvean on random vibration of road vehicles travelling with varying velocity. The topic of random vibration fitted to my interest in stochastic differential equations, whereas degrading effects of dynamics, such as fatigue were important for the reliability of engineering materials and structures.

I think I should add here that at the same time I was afraid of "loosing" my quite an extensive knowledge and research experience in the analysis of wave propagation. So, around 1980 I decided to write a book which would summarize my and other existing results on stochastic waves. Such a book was published in Polish in 1982 ("Fale Stochastyczne", PWN, Warsaw) and its extended version – in English: "Stochastic Wave Propagation", Elsevier, 1985. Undoubtedly, this was a good decision; work on this book gave me much intellectual satisfaction and to some extent made my name recognizable.

So, starting from early eighties my research interest has almost entirely been concentrated on my new field: stochastic dynamics of engineering systems and random fatigue of materials. This field having been quite new and attractive about thirty years ago, still remains a lively and important subject of scientific endeavour. My long work in this domain has brought me much joy and intellectual satisfaction; it also allowed me to participate in the international research collaboration.

It is not my intention to write here about all my exciting connections with various research institutions and many professional colleagues. However, I feel I should make some exceptions.

First, I wish to mention my visiting professorship at the Technical University of Denmark (Lyngby) in 1985 due to the invitation of Professor Ove Ditlevsen; it was great to do joint research with Ove, to lecture on stochastic differential equations for applications and to write the Lecture Notes on this topic (nicely published at Lyngby), which later – modified and extended – were published as the book “Stochastic Differential Equations with Applications to Physics and Engineering”, Kluwer, Dordrecht, 1991.

The second important “event” is my long-standing, very effective collaboration with Professor Billie F. Spencer at the University of Notre Dame (Indiana – USA). This collaboration started in 1990 when I was offered there the Melchor Endowed Visiting Professorship for 1990/91. Later I held – the Massman Visiting Professorship for the academic year 1997/98. In the meantime (1993-97) we did research with Bill on random fatigue within the joint USA – Poland research project of Maria Skłodowska-Curie. This decade of joint work resulted in several research papers and two books: Sobczyk K., Spencer B.F., “Random Fatigue: from Data to Theory”, Academic Press, Boston, 1992; Sobczyk K., Kirkner D.B., “Stochastic Modelling of Microstructures”, Birkhauser, Boston, 2002. This long time of collaboration was really a great experience for me both, professionally and socially.

And, finally, writing about my ties with the USA science I wish to mention my very close relations with Professor Y.K. Lin – a renowned scientist in stochastic dynamics leading, during above than twenty years, the Stochastic Research Center at the Florida Atlantic University (Boca Raton). Those who have met Mike (a popular first name of Y.K. Lin) are impressed by his great culture and honesty in the scientific work. My two visits to Boca Raton (in 1988 and 2004) as the invited visiting professor were scientifically highly valuable and enjoyable.

The second “channel” of my ties with the international research activity was the scientific conferences. Presentation of my research work at various scientific meetings has given me a strong feeling of the unity of science – in spite of various human experiences. The conferences which I regard as especially rewarding for me were the following: the Workshop at Lyngby (1982) organized by Professor Ove Ditlevsen; the Weibull Memoriam – IUTAM Symposium in Stockholm (1984) organized by Professors S. Eggwertz and N.C. Lind; the IUTAM Symposia on Stochastic Dynamics: in Igls/Innsbruck (1987) organized by Professors G. Schuëller and F. Ziegler; in Torino (1991) organized by Professors N. Bellomo and F. Casciati, and in Trondheim (1995) organized by Professors A. Naess and S. Krenk; the “Spanos conferences” on Stochastic Computational Mechanics organized by Professor P. Spanos (Athens – 1994, Santorini – 1998, Corfu – 2002); the conferences in the USA, e.g. in Blacksburg – Virginia (1988) organized by Professors R.A. Heller and M.P. Singh, in Denver – Colorado (1992) organized by Professors R.B. Corotis and Y.K. Lin, in Worcester – Massachusetts (1996) organized by Professor M.N. Noori, in Notre Dame – Indiana (1998) organized by Professors B.F. Spencer and E.A. Johnson; and finally: the conference on Nonlinear Mechanics and Stochastic Dynamics in Waterloo – Canada (1993) organized by professors: W. Kliemann and S.Namachchivaya.

Stochastic dynamics of engineering systems was also a subject which I had a honour to present in the highly prestigious invited plenary lecture at the XXI-st World IUTAM Congress of Theoretical and Applied Mechanics, Warsaw, 2004 (organized by professors: W. Gutkowski and T. Kowalewski).

However, this what has been especially wonderful during all this long time was my deep feeling that the world community on Stochastic Mechanics constitutes a unique group of friends. Today I greatly appreciate that many of these friends are here in Warsaw – participating in our special meeting – the International Conference on Stochastic Methods in Mechanics: Status and Challenges (Warsaw, September 28-30, 2009).