# RESEARCH ACTIVITY OF THE LATE PROFESSOR KAZIMIERZ SOBCZYK (1939-2017)

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Stochastic mechanics is subject area concerning modeling mechanical problems by using random variables and stochastic processes to reflect all model uncertainties. It started extensive development at early sixties of the twentieth century, which coincided with the beginning of research activity of the late Prof. Kazimierz Sobczyk. During next decades Prof. Kazimierz Sobczyk made research in various areas of stochastic mechanics including: stochastic dynamical systems, stochastic wave propagation, modeling of random materials, fracture mechanics, micromechanics, information-theory based methods and many others. A complete list of his publications can be found in the Preface [34] to the special issue of Probabilistic Engineering Mechanics which was dedicated to Prof. Kazimierz Sobczyk on the occasion of his 70th birthday, containing post-conference papers of the Int. Conf. ''Stochastic Methods in Mechanics: Status and Challenges'' held in Warsaw, on Sept. 28–30, 2009. In the following sections we briefly present main topics of scientific interests and research achievements of Prof. Kazimierz Sobczyk with representative references.

**Stochastic dynamics**: Contributions made by Professor Kazimierz Sobczyk to the subject area of stochastic dynamics (random vibrations theory) were often of pioneering nature. Such was e.g. the paper dealing with free vibrations of an elastic plate with random stiffness (which lead to the random eigenvalue problem [2]. The paper [4] was one of the first contributions to the problem of random vibrations of composite plates. Also an important issue of non-Gaussianity of response of vibratory systems was dealt with by Professor Kazimierz Sobczyk [5-8]. Of original nature were also the applications of maximum entropy principle [9-12]. Book [1] presents most fundamental methods known in stochastic dynamics at the time.

**Stochastic waves:** The first problem undertaken by Professor Kazimierz Sobczyk in the area of stochastic wave propagation was scattering of elastic waves at randomly rough surfaces [14]. A plane harmonic elastic wave incident at the random surface separating two different elastic half-space was considered and the probabilistic structure of the scattered field at some observation point was determined. Next he considered scattering of elastic surface (Rayleigh) waves at a random boundary of an elastic body [15]. Studies in this subject area were continued and the findings published in a number of papers and collected in a book [13].

**Stochastic differential equations:** The book [16] provides an account of basic results of the theory of stochastic differential equations. It also covers most important concepts and results of stochastic processes and stochastic calculus theory. Some of most effective methods of solution of stochastic differential equations as well as examples of applications to vibration problems are given.

**Stochastic approach to fatigue:** Professor Kazimierz Sobczyk made a contribution to problems of stochastic modeling of fatigue phenomena through his innovative approaches, such as e.g. modeling of fatigue accumulation in terms of Markov chains [18], or modeling of fatigue crack growth as a cumulative jump process (driven by a random counting process) [19-23]. He also developed some stochastic models of stiffness degradation of vibratory systems [24-26]. The book [17] presents most important methods of stochastic modelling of fatigue fracture of engineering materials.

**Stochastic modelling of microstructures:** Research done in the area of micromechanics was focused on reconstruction of random grain structure from incomplete empirical information [29], characterization of crack growth in elastic material with a random array of small defects [30] and characterization of random microstructural stresses and fracture estimation [31]. Most important methods of stochastic modelling of microstructures were collected in the book [27].

**Stochastic information-theoretic modelling:** Professor Kazimierz Sobczyk also developed a theoretic information approach (based on the concept of entropy) to identification, signal processing and dynamics of

stochastic systems [32], [33].

**References:**

[1] K. Sobczyk, *Methods of Statistical Dynamics* (in Polish), Polish Scientific Publishers, Warsaw, 1973.
[2] K . Sobczyk, Free vibrations of elastic plate with random properties - the eigenvalue problem*, Journal of Sound and Vibration,* 22(1) 33-39, 1972.
[3] K. Sobczyk, D.B. Macvean, J.D. Robson, Response to profile-imposed excitation with randomly varying traversal velocity*, Journal of Sound and Vibration*, 52 (1) 37-49, 1977.
[4] M. Witt, K. Sobczyk, Dynamic response of laminated plate to random loading, *Int. J. Solids and Structures*, 16(2) 231-238, 1980.
[5] Z. Kotulski, K. Sobczyk, Linear systems and normality, *Journal of Statistical Physics,* 24(2) 359-373, 1981.
[6] R. Iwankiewicz, K. Sobczyk, Dynamic response of linear structures to correlated random impulses, *Journal of Sound and Vibration*, 86(3) 303-317, 1983.
[7] Z. Kotulski, K. Sobczyk, Characteristic functionals of randomly excited physical systems, *Physica* A, 123(1) 261-278, 1984.
[8] Z. Kotulski, K. Sobczyk, Effects of parameter uncertainty on the response of vibratory systems to random excitation, *Journal of Sound and Vibrations*, 119(1) 159-171, 1987.
[9] K. Sobczyk, J. Trębicki, Maximum entropy principle in stochastic dynamics, *Prob. Eng. Mech.,* 5(3) 102-110, 1990.
[10] K. Sobczyk, J. Trębicki, Maximum entropy principle and nonlinear stochastic oscillators, *Physica A,* 193(3-4) 448-468, 1993.
[11] J. Trębicki, K.Sobczyk, Maximum entropy principle and non-stationary distributions of stochastic systems, *Probabilistic Engineering Mechanics*, 11(1) 169-178, 1996.
[12] K. Sobczyk, J. Trębicki, Approximate probability distributions for stochastic systems: maximum entropy method, *Computer Methods in Applied Mechanics and Engineering*, 168(1-4) 91-111, 1999.
[13] K. Sobczyk, *Stochastic Wave Propagation, Elsevier, Amsterdam, 1985.*
[14] K. Sobczyk, Scattering of plane wave at a random surface, *Proc. Vibr. Problems*, 6(1) 99-109, 1965.
[15] K. Sobczyk, Scattering of Rayleigh waves at a random boundary of an elastic body, *Proc. Vibr. Problems,* 7(4) 363-374, 1966.
[16] K. Sobczyk, *Stochastic Differential Equations with Applications to Physics and Engineering,* Kluwer, 1991.
[17] K. Sobczyk, B.F. Spencer. Jr., *"Random Fatigue: From Data to Theory",* Academic Press, Boston, 1992.
[18] K. Sobczyk, On the Markovian models for fatigue accumulation, *J. Mec. Theor. et Appl.,* N. spec., 147-160, 1982.
[19] K. Sobczyk, Stochastic models for fatigue damage of materials, *Adv. Appl. Probability,* 19(3) 652-673, 1987.
[20] O. Ditlevsen. K. Sobczyk, Random fatigue crack growth with retardation, *Eng. Frac. Mech.*, 24(6) 861-878, 1986.
[21] K. Sobczyk, J. Trębicki, Modelling of random fatigue by cumulative jump processes, *Eng. Frac. Mech.*, 34(2) 477-493, 1989.
[22] K.Sobczyk, J.Trębicki, Cumulative jump-correlated model for random fatigue, *Eng. Frac. Mech.,* 40(1) 201-210, 1991.
[23] K. Sobczyk, J. Trębicki, B.F. Spencer, Modelling of curvilinear fatigue crack growth, *Eng. Frac. Mech.*, 52(4) 703-715, 1995.
[24] K. Sobczyk, J. Trębicki, Stochastic dynamics with fatigue-induced stiffness degradation, *Prob. Eng. Mech.,* 15(1) 91-99, 2000.
[25] J. Trębicki, K. Sobczyk, On nonlinear stochastic vibratory systems with stiffness degradation, *Acta Mechanica*, 195(1-4) 203-214, 2008.
[26] K. Sobczyk, K. Perros, C. Papadimitriou, Fatigue reliability of multi-dimensional vibratory degrading systems under random loading, *ASCE Journal of Engineering Mechanics*, 136(2) 179-188, 2010.
[27] K. Sobczyk, D.J. Kirkner, *Stochastic Modelling of Microstructures,* Birkhauser, Boston, 2001.
[28] K. Sobczyk, (Ed.), *Random Material Microstructures: Modelling and Mechanical Behaviour,* IPPT PAN, Warszawa, 2004.
[29] K. Sobczyk, Reconstruction of random material microstructures; patterns of maximum entropy, *Prob. Eng. Mech.*, 18(4) 279-287, 2003.
[30] K. Sobczyk, J. Trębicki, A.B. Movchan, Crack path in an elastic material with a random array of small defects, *Intern. J. of Fracture*, 125(1-2) 103-123, 2004.
[31] K. Sobczyk, J. Trębicki, A.B. Movchan, Characterization of random microstructural stresses and fracture estimation, *European J. of Mech./A-Solids*, 25(1) 573-591, 2007.
[32] K. Sobczyk, Information Dynamics: Premises, Challenges and Results, *Mech. Systems & Signal Processing*, 15(3) 475-498, 2001.
[33] K. Sobczyk, P. Hołobut, Information-theoretic approach to dynamics of stochastic systems, *Prob. Eng. Mech.,* 27(1) 47-56, 2012.
[34] R. Iwankiewicz, Z. Kotulski, Preface to Special Issue: Stochastic Methods in Mechanics -Status and Challenges, *Probabilistic Engineering Mechanics,* 26(1) 1-4, January 2011. https://doi.org/10.1016/j.probengmech.2010.07.004