

Randomness in Physics and Complexity

Vazha (Vaja) Tarieladze

Department of Probabilistic and Statistical Methods

Muskhelishvili Institute of Computational Mathematics

And

Department of Computational Mathematics

Georgian Technical University

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This talk is dedicated to 245-th birthday of Scottish botanist and [palaeobotanist](#)

Robert Brown, 21.XII. 1773—10.VI. 1858



who made important contributions to botany largely through his pioneering use of the microscope.

In 1827 Robert Brown noticed that if you looked at pollen grains in water through a microscope, the pollen jiggles about, but Brown couldn't understand what was causing it. He thought at first the pollen must be alive, but after testing the phenomenon with fine dust particles, he

confirmed that the movement was not due to any living organism.

Now this jigglng is called 'Brownian motion'.

From Wikipedia:

This motion is named after the botanist [Robert Brown](#), who was the most eminent microscopist of his time. In 1827, while looking through a microscope at pollen of the plant *Clarkia Pulchella* immersed in water, the triangular shaped pollen burst at the corners, emitting particles which he noted jiggled around in the water in random fashion. He was not able to determine the mechanisms that caused this motion.

I wanted very much to tell you the name of a person who elaborated this name, but still I do not know this.

I found that **Charles Darwin** knew about Brown's observation: he wrote in 1830:

"I called him two or three times before my voyage in the *Beagle* [1831], and on one occasion he asked me to look through a microscope. This I did...I then asked him what I had seen; but he answered me, 'That is my little secret'".

I found also that **Robert Brown** was not the first who observed the **Brownian motion!**

Dutch [physiologist](#), [biologist](#) and [chemist](#)

Jan Ingenhousz (8 December 1730 – 7 September 1799)



In 1785, described the irregular movement of coal [dust](#) on the surface of alcohol and therefore has a claim as discoverer of what came to be known as [Brownian motion](#).

After Brown during almost 30 years almost nothing was made for understanding of nature of Brownian motion.

German mathematician

Ludwig Christian Wiener

(7 December 1826 [Darmstadt](#) – 31 July 1896 [Karlsruhe](#))

in 1863 attempted to explain [Brownian motion](#) as a result of atomic structure of the liquid . However Chr. Wiener believed the existence of aether atoms too.

Chr. Wiener' theory was criticized by R. Meade Bache in a paper published in Proc. American Phil. Soc. , Volume 33 (1894).

The curious thing was, that while most scientists were convinced that atoms existed, because the atomic theory was able to explain many physical and chemical processes, having a mathematical account does not prove that atoms exist and by the beginning of the 20th century, nobody had been able to produce an experimental proof of their existence

In 1905, **Einstein** became interested in the phenomenon of Brownian Motion, and in the same year he published three papers which finally came up with an explanation.

Einstein realised that the jiggling of the pollen grains seen in Brownian motion was due to molecules of water hitting the tiny pollen grains, like children randomly kicking a ball in a playground. The pollen grains were visible but the water molecules were not, which was why it looked like the pollen was bouncing around on its own.

Einstein also showed that it was possible to work out how many molecules were hitting a single pollen grain and how fast the water molecules were moving - all by looking at the pollen grains.

Einstein's papers together with the independent work of the Polish scientist

Marian Smoluchowski (1872-1917)



in 1906 brought the solution of the problem to the attention of physicists, and presented it as a way to indirectly confirm the existence of atoms and molecules.

At last scientists had made predictions about the properties of atoms that could actually be tested. The French physicist

Jean Perrin (1870-1942)

then used Einstein's predictions to work out the size of atoms and remove any remaining doubts about their existence.

American mathematician, 'the father of Cybernetics'

Norbert Wiener

(November 26, 1894 March 18, 1964 (aged 69))



Influenced by Jean Perrin's works, In his paper

"Differential-Space"

Journal of Mathematics and Physics 2, 131-174 (1923)

Created a mathematical model of Brownian motion, which is now called

Wiener Process.

From this work of Norbert Wiener originates

Stochastic Analysis

And

Theory of Probability Distributions on Linear Spaces

The last theory found its applications in

Information- Based Complexity

In the famous monograph by

Traub, J. F., Woźniakowski, H., and Wasilkowski, G. W.

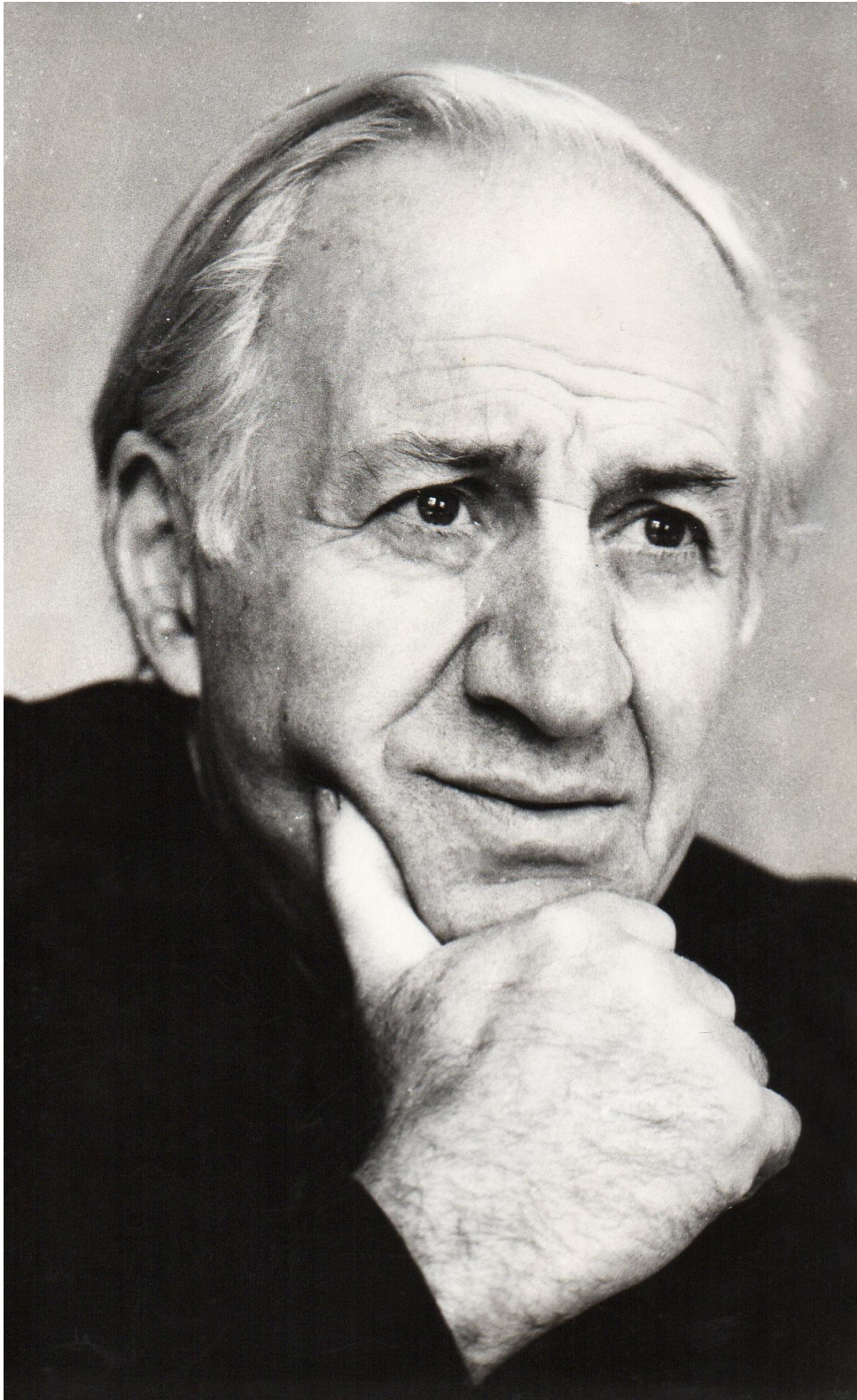
Information-Based Complexity.

New York: Academic Press. (1988).

The monograph of

Nicholas Vakhania

(August 28, 1930-July 23, 2014)



- Probability distributions on linear spaces

- New York : North Holland, 1981.

Is one of the most referred sources.

Let me recall that N. Vakhania was the director of MICM in 1978-2006.

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