Smoluchowski Symposia: Why are we here?

P. F. Góra

Faculty of Physics, Astronomy and Applied Computer Sciences
Jagiellonian University

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Marian Smoluchowski, 1872-1917

A lecture by Professor Peter Hänggi

http://www.physik.uni-augsburg.de/theo1/hanggi/Smoluchowski_oeuvre.pdf

Statistical Physics

Physics of large, composite systems, consisting of **many** small parts.
Only the “macroscopic” properties are observed.

50% of all physics?!

Applications in many areas of physics and *outside* physics.

Statistical physics:

- classical thermodynamics and beyond
- kinetic theory of matter
- chemical kinetics
- solid state and soft matter physics
- spin systems (Ising, Potts, . . .)
- phase transitions, renormalization group
- nonlinear science (chaos, synchronization, . . .)
- nonextensive thermodynamics
- complex systems (collective behaviour, self-organization)
- random matrices
- networks and graphs (random, scale free, small-world)
- econophysics, biological physics, bioinformatics
- stochastic processes (noise)

Discovery of Brownian motion, 1827

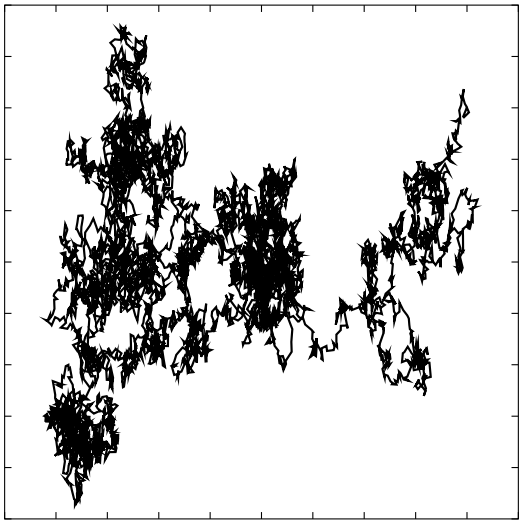
Robert Brown
(1773–1858)
a Scottish
botanist

While examining the form of these particles immersed in water, I observed many of them very evidently in motion. . . These motions were such as to satisfy me, after frequently repeated observations, that they arose neither from currents in the fluid, nor from its gradual evaporation, but belonged to the particle itself.

In fact, Brown was not the first to observe these bizarre movements, but before Brown the movements had been observed mostly in organic matter and their origin was attributed to a *vital force*. Brown observed the motion of active pollen, dead pollen and inorganic suspension.

Strange properties of Brownian motion

- Very irregular
- The trajectory looks similar over many time scales



- The trajectory does not depend of history

All attempts to describe the motion by measuring velocities failed.

Two papers that explained everything

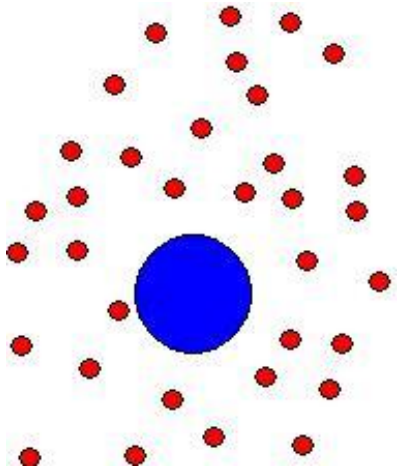
Albert Einstein
(1879–1955)

A. Einstein, *Über die von der molekularkinetischen Theorie der Wärme geforderte Bewegung von in ruhenden Flüssigkeiten suspendierten Teilchen*, Ann. Phys. 17, 549–560 (1905).

Marian
Smoluchowski
(1872–1917)

M. von Smoluchowski, *Zur kinetischen Theorie der Brownschen Molekularbewegung und der Suspensionen*, Ann. Phys. 21, 756–780 (1906).

Molecular explanation



$$\left\langle x^2 \right\rangle \sim t$$

We cannot trace all molecules — we replace their deterministic effects by random *noise*.

The trajectory is never differentiable.

Gaussian White Noise $\leftrightarrow$ *equilibrium* fluctuations.

Gaussian noises are mathematically “easy” to treat.

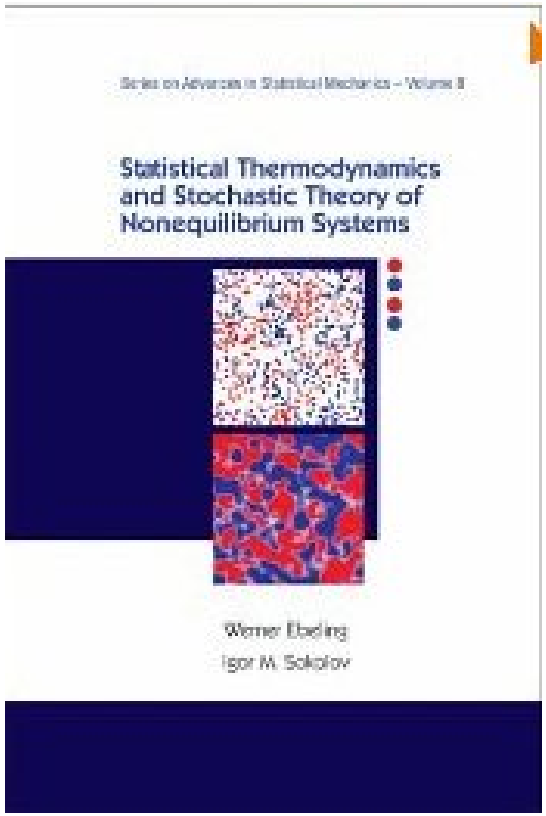
Huge success

This theory proved to be a huge success. It served as a molecular explanation of diffusion and provided decisive support in favour of the atomistic theory of matter (Jean Perrin, Nobel Prize, 1926).
In the coming decades, after overcoming many formal difficulties and along with the development of mathematical theory of stochastic processes, it would be applied to explain

- chemical kinnetics
- stochastic resonance
- Brownian ratchets
- molecular motors
- biological physics at the (sub)cellular level
- stochastic paradoxes
- signal processing
- provide ground for Monte Carlo simmulations
- many others.

New developments: Nonequilibrium systems

Fluctuations in nonequilibrium systems: long memory and fractal noises, anomalous diffusion $\langle x^2 \rangle \sim t^\alpha$, new phenomena explained, new mathematical formalism.



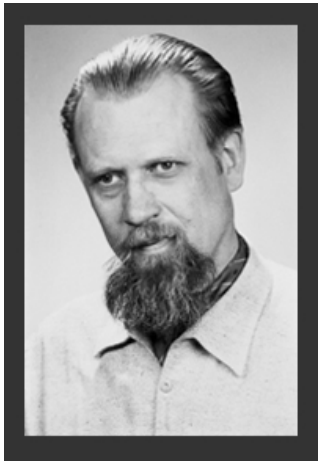
Marian Smoluchowski Symposia: A need to form a community

Prof. Andrzej Fuliński

Prof. Jan Popielawski

Need to spend money. Need to go hiking.

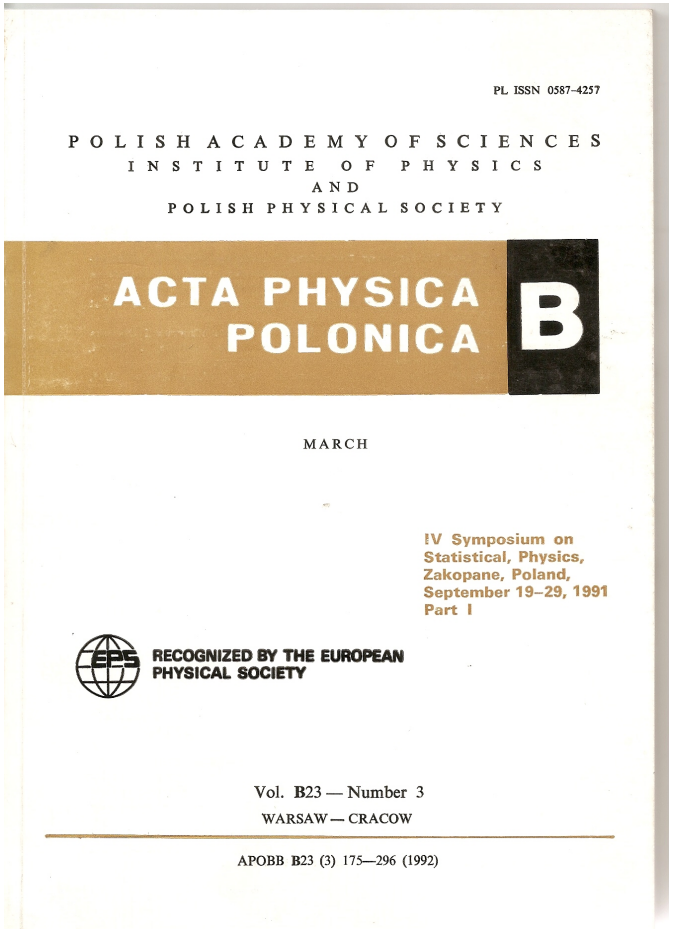
Symposium on Statistical Physics, Zakopane, Poland, September 1988



Prof. Gert Eilenberger

Prof. Jarosław Piasecki

Dr. Ryszard Zygadło

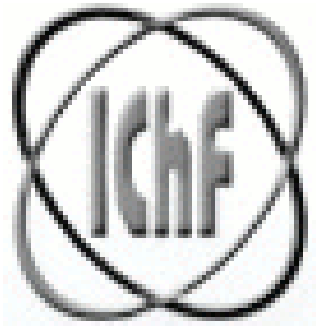


1992 — first Proceedings published in *Acta Physica Polonica B*, a journal indexed in WoS.

1997 — name **Marian Smoluchowski Symposium on Statistical Physics** adopted.
Late ’90s — access to European funding.

The co-organizers

Jagiellonian University



Institute of Physical Chemistry

University of Warsaw

University of Silesia

Silesian University of Technology

Wrocław University of Technology

The community has formed

Regular participants from Gdańsk, Gliwice, Katowice, Kielce, Kraków, Opole, Poznań, Szczecin, Toruń, Warsaw, Wrocław.

Regular lecturers and participants from Belgium, Brazil, Germany, Italy, Russia, Spain, USA.

Prof. Katja Lindenberg: *This is my community.*

Future of statistical physics

- new applications
- new phenomena explained
- (some) outstanding problems solved
- formal advancements
- etc

New “big” discoveries