



THE  
ABEL  
PRIZE  
2014

The Norwegian Academy of Science and Letters  
has decided to award the Abel Prize for 2014 to

## Yakov G. Sinai

Princeton University and Landau Institute for Theoretical Physics,  
The Russian Academy of Sciences

**“for his fundamental contributions to dynamical systems,  
ergodic theory, and mathematical physics”**

Ever since the time of Newton, differential equations have been used by mathematicians, scientists and engineers to explain natural phenomena and to predict how they evolve. Many equations incorporate stochastic terms to model unknown, seemingly random, factors acting upon that evolution. The range of modern applications of deterministic and stochastic evolution equations encompasses such diverse issues as planetary motion, ocean currents, physiological cycles, population dynamics, and electrical networks, to name just a few. Some of these phenomena can be foreseen with great accuracy, while others seem to evolve in a chaotic, unpredictable way. Now it has become clear that order and chaos are intimately connected: we may find chaotic behavior in deterministic systems, and conversely, the statistical analysis of chaotic systems may lead to definite predictions.

Yakov Sinai made fundamental contributions in this broad domain, discovering surprising connections between order and chaos and developing the use of probability and measure theory in the study of dynamical systems. His achievements include seminal works in ergodic theory, which studies the tendency of a system to explore all of its available states according to certain time statistics; and statistical mechanics, which explores the behavior of systems composed of a very large number of particles, such as molecules in a gas.

Sinai's first remarkable contribution, inspired by Kolmogorov, was to develop an invariant of dynamical systems. This invariant has become known as the Kolmogorov–Sinai entropy, and it has become a central notion for studying the complexity of a system through a measure-theoretical description of its trajectories. It has led to very important advances in the classification of dynamical systems.

Sinai has been at the forefront of ergodic theory. He proved the first ergodicity theorems for scattering billiards in the style of Boltzmann, work he continued with Bunimovich and Chernov. He constructed Markov partitions for systems defined by iterations of Anosov diffeomorphisms, which led to a series of outstanding works showing the power of symbolic dynamics to describe various classes of mixing systems.

With Ruelle and Bowen, Sinai discovered the notion of SRB measures: a rather general and distinguished invariant measure for dissipative systems with chaotic behavior. This versatile notion has been very useful in the qualitative study of some archetypal dynamical systems as well as in the attempts to tackle real-life complex chaotic behavior such as turbulence.

Sinai's other pioneering works in mathematical physics include: random walks in a random environment (Sinai's



walks), phase transitions (Pirogov–Sinai theory), one-dimensional turbulence (the statistical shock structure of the stochastic Burgers equation, by E–Khanin–Mazel–Sinai), the renormalization group theory (Bleher–Sinai), and the spectrum of discrete Schrödinger operators.

Sinai has trained and influenced a generation of leading specialists in his research fields. Much of his research has

become a standard toolbox for mathematical physicists. His works had and continue to have a broad and profound impact on mathematics and physics, as well as on the ever-fruitful interaction of these two fields.

