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Laudatio for David Ruelle

Op 20 april 1999 werd in de Aula van het Academiegebouw te Groningen de achtste Bernoulli-lezing gehouden. Spreker was de mathematisch fysicus David Ruelle uit het Institut des Hautes Etudes Scientifiques te Bures-sur-Yvette nabij Parijs. Ruelle is onder meer beroemd door het wiskundige formalisme dat hij voor de Thermodynamica gaf. Dit formalisme is ook van groot belang voor de theorie van Dynamische Systemen. Samen met Floris Takens schreef Ruelle in 1971 een baanbrekend artikel getiteld On the nature of turbulence**, in de Communications of Mathematical Physics.**

Hieronder staat de op 20 april door Floris Takens uitgesproken laudatio voor David Ruelle. Daarna volgt de tekst van Ruelle's Bernoulli-lezing. Op de dag van de lezing werd door Henk Broer een inleiding voor leraren gehouden over dynamische systemen en chaostheorie, het gebied waarop de banden tussen Ruelle en Groningen het nauwst zijn. Onder de titel The how and what of chaos **is een uitwerking van deze inleiding opgenomen na Ruelle's lezing.**

It is a pleasure for me to introduce to you David Ruelle who will give the Johann Bernoulli lecture for the academic year 1998 - 1999.

David Ruelle was born in Ghent (1935), he studied civil engineering in Bergen (Mons) and mathematics and physics in Brussels. He prepared his Ph.D. thesis under the supervision of professor Jost of the Eidgenössische Technische Hochschule (E.T.H.) in Zürich, leading to a doctorate in physics, on quantum field theory, in 1959 at the university of Brussels. After this he worked as a visiting researcher at the E.T.H. and was during two years a member of the Institute of Advanced Studies in Princeton. Since 1964 he is a professor at the Institute des Hautes Études Scientifiques in Bures-sur-Yvette (France).

This institution is not part of a university and is not devoted to industrial research: it is dedicated to the pursuit of pure science. This situation, which may now seem archaïc to some, could be maintained through the extremely high quality and international recognition of the research at this institution.

The work of Ruelle belongs to the area often denoted as mathematical physics, and more in particular, statistical mechanics and non-linear dynamics (or chaos theory).

His work, in the sixties, was devoted to statistical mechanics. This is the theory which tries to explain the macroscopic properties, like the relation between temperature, pressure, and density, of materials on the basis of the interactions between the (many) molecules or atoms. So it analyses the collective properties of a big collections of equal components, of which we know the properties as well as the way in which they interact.

This relation between the properties of the individual components and the collective behaviour is often quite unexpected: one may think of the behaviour of a crowd of human beings.

Ruelle mainly contributed here to the general theory of equilibria and phase transitions of these (infinitely) large systems. He was especially concerned with the mathematical foundation of these concepts: the subtitle of his book on statistical mechanics in 1969 is 'Rigorous Results' (although it starts with a quotation by F. Kafka: 'Richtiges Auffassen einer Sache und Missverstehen der gleichen Sache schliessen einander nicht vollständig aus'). The condition for equilibrium in classical, as opposed to quantum, systems now carries the name of Dobrushin-Lanford-Ruelle condition.

Around 1970 his interests went in the direction of turbulence and the various explanations for this phenomenon. The standard theory, due to Hopf and Landau-Lifschitz, was that the seemingly unpredictable motion one observes in turbulence is due to the large number of effective degrees of freedom. In that period there was a strong progress in the geometric theory of dynamical systems, due mainly to S. Smale and his (former) students. Ruelle then realized that the new results might have relevance for the problem of turbulence: it became apparent that there was no logical necessity for a large number of degrees of freedom in order to get turbulent behaviour. This implied that other approaches to turbulence should at least be tried. These ideas were first received with scepticism.

At present there is solid experimental evidence that non-linear effects are responsible for seemingly unpredictable dynamics in a number of cases, including the onset of turbulence in the Couette-Taylor experiment, the chemical reaction studied by Belousov and Zhabotinskii, the motion of Hyperion, a satellite of Saturn, et cetera, et cetera.

The original scepticism changed into the opposite: under the name of Chaos theory these ideas became popular and even found their way to the general public. The key role of Ruelle in this development is well described in the book *Chaos: the making of a new sience* by the American journalist James Gleick.

I should mention here that in this first period of making the connection between the mathematical theory of dynamical system and the physical theory of turbulence I had the pleasure to cooperate with Ruelle. I have still very good memories of that period.

Apart from propagating non-linear and chaotic dynamics as a tool to understand certain experimental phenomena, Ruelle also contributed in a very important way to the mathematical theory of chaotic dynamics.

In a vague sense there is an analogy between the main problem in statistical mechanics: understanding the collective behaviour of a large (or infinite) collection of equal individuals and one of the main problems in dynamics: understanding the long term (statistical) properties of the motion obtained by iterating a fixed transformation very often. This may seem very vague but Ruelle (and Sinai) succeeded in making this idea useful and actually applied the methods of statistical mechanics to nonlinear dynamics, where we now have notions like the 'thermodynamic formalism' and the 'Sinai-Ruelle-Bowen measures'.

Apart from these contributions, which are of a very technical nature, he also expressed his ideas about chaos and its relation to chance (or probability) in a non-technical exposition which was published by Penguin Books under the title *Chance and Chaos*. Here he does not restrict to mathematics and physics but touches upon subjects like: economy, boiling water and the gates of hell, the true meaning of sex, and others.

I want to conclude this introduction by mentioning that I had to be rather incomplete: the time is limited and also I had to avoid speaking of things I don't know well enough. From his work on quantum field theory I just mention his contribution to what has become known as the Haag-Ruelle scattering theory and the, in view of his personality, somewhat inappropriately called 'Rage Theorem'. I thereby completely passed over his recent work on non-equilibrium statistical mechanics.

Acknowledgement

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References

[G,1987] J. Gleick, *Chaos, the making of a new science*, Viking Press, New York, 1987.

[R,1969] D. Ruelle, *Statistical mechanics*, Benjamin, 1969.

[R,1991] D. Ruelle, *Chance and chaos*, Princeton Univ. Press 1991, Penguin Books 1993, translated as *De wetten van toeval en chaos*, Aramith Uitgevers'.