International Research Center on
MATHEMATICS AND MECHANICS OF COMPLEX SYSTEMS

and

FONDAZIONE TULLIO LEVI CIVITA

KAZUO AOKI

Kazuo Aoki was born in Kyoto, Japan in 1950. He obtained his degrees of Bachelor of Engineering (in 1973) and Master of Engineering (in 1975) at the Department of Aeronautical Engineering, Kyoto University. Then, he obtained the degree of Doctor of Engineering at the same department in 1979. During his master and doctoral studies, his official supervisor was Professor Ko Tamada, but he was practically supervised by Professor Yoshio Sone in the same group all the time. His doctoral thesis was on the forces acting on a body in a slightly rarefied gas and consisted of a series of works in the framework of Sone's asymptotic theory of the boundary-value problem of the Boltzmann equation for small Knudsen numbers (or small mean free paths).

After he obtained a position of Research Associate at the Department of Aeronautical Engineering, Kyoto University, he worked at the Department of Mathematics, Politecnico di Milano as a visiting researcher for two years (1981-1983) under the supervision of Professor Carlo Cercignani. Kazuo Aoki's work has been influenced by the two supervisors, Sone and Cercignani, and in particular, his friendship with Cercignani for many years gave him opportunities to know many Italian mathematical physicists. Kazuo Aoki was appointed as Associate Professor in 1985 and then Professor in 1994 always at the Department of Aeronautical Engineering, Kyoto University. In 1991, he was invited to the Laboratoire de Modélisation en Mécanique, Université Pierre et Marie Curie (Paris 6) as Invited Professor by Professor Henri Cabannes, who introduced Kazuo Aoki to French school of mathematical kinetic theory. This was the start of his long collaboration with French mathematicians, such as Claude Bardos, Pierre Degond, and François Golse. He is now Professor in Molecular Fluid Dynamics at the Department of Mechanical Engineering, Kyoto University.

Kazuo Aoki is member of:

- the Japan Society for Aeronautical and Space Sciences;

- the Physical Society of Japan;

- the Japan Society for Industrial and Applied Mathematics;

- the Association of Aerosol Science and Technology;

- the American Physical Society;

- the American Institute of Aeronautics and Astronautics

- president of the Japan Society of Fluid Mechanics.

The spectrum of the scientific activity of Kazuo Aoki is very wide. Several different methodologies have been employed in the research, mostly based on numerical simulations considered by the scientific community very accurate and reliable.
Kazuo Aoki is author of more than 150 widely quoted research articles and books.

Let us mention a few of the directions he has worked on:

Asymptotic analysis for the Boltzmann equation: Fluid-dynamic description for near continuum flows: The behavior of a gas in the near continuum regime is investigated by a systematic asymptotic analysis for the Boltzmann equation, and fluid-dynamic descriptions for gas flows are established in various physical situations. In particular, the effect that infinitesimal gas motion may have a finite effect on the temperature field in the continuum limit (ghost effect) was discovered. (Ref.s 1 and 2)

Numerical analysis of the linearized and nonlinear Boltzmann equations: Accurate numerical analysis by a finite-difference method is performed for the linearized Boltzmann equation, and numerical solutions for fundamental problems (Poiseuille flow, thermal transpiration, temperature jump, etc.), which serve as standard solutions, were established. The analysis was then extended to linearized as well as nonlinear Boltzmann equations for gas mixtures. (Ref.s 3 and 4)

Vapor flows with evaporation and condensation on the boundary: Vapor flows with evaporation and/or condensation on the boundary, which are a typical nonequilibrium phenomenon, are investigated theoretically and numerically on the basis of kinetic theory, and some fundamental properties have been clarified. For instance, the parameter relations that give a steady solution in a half space for evaporation/condensation on a place condensed phase are clarified numerically, and the fact that a tiny amount of a noncondensable gas can have a large effect on flows

of a vapor in the continuum regime was discovered. (Ref.s 5 and 6)

Flow induced by temperature fields: In a gas under low-pressure circumstances or in micro-scales, temperature fields can induce flows without the help of an external force. Various types of such flows (thermal transpiration, thermophoresis, thermal-stress flows, etc.) are investigated analytically and numerically on the basis of kinetic theory. In particular, a new type of flow induced by the presence of a sharp edge (thermal edge flow) is discovered. (Ref.s 7 and 8)

Diffusion models for gas flows in micro channels: Under thin-channel approximations, a partial differential equation of convection-diffusion type describing gas flows in a micro channel are derived systematically from the Boltzmann equation. Then, it is applied to the Knudsen pump and its variants, and their fundamental properties were clarified.

Mechanical model for the friction: A mechanical body is immersed in a free gas at equilibrium (in the mean-field approximation), performing elastic or diffusive collisions (at same temperature). The body is subject to the action of a constant external field. Due to the recollisions, analytic and numerical results shows that the asymptotic velocity is reached with a power law (not exponentially) (Ref. 11).

As shown by previous list, the unifying feature of the scientific activity of Kazuo Aoki is the systematic use of the Kinetic theory which had in his two advisors, Cercignani and Aoki, two of the most famous exponents, as a tool for the modelization. His point of view was however always pointing toward practical applications, driven to that by his Engineering formation. On the other hand, his capability of working on theoretical aspects allowed him to interact fruitfully with mathematicians and physicists. Is this rare capability of creating a bridge between the two scientific communities, whose interactions are often difficult, that makes of Kazuo Aoki the ideal winner of the Levi Civita prize. For this among all the other reported reasons, the committee, entrusted by the “Fondazione Levi-Civita” and the Scientific Committee of the International Research Center MEMOCS with the responsibility of awarding the

International Levi-Civita Prize

unanimously proposes Professor Kazuo Aoki as winner of the 2013 edition.

1. Y. Sone, K. Aoki, S. Takata, H. Sugimoto, and A. V. Bobylev, “Inappropriateness of the heat-conduction equation for description of a temperature field of a stationary gas in the continuum limit: Examination by a asymptotic analysis and numerical computation of the Boltzmann equation,” Phys. Fluids 8(2), 628-638 (1996).
2. S. Takata and K. Aoki, “The ghost effect in the continuum limit for a vapor-gas mixture around condensed phases: Asymptotic analysis of the Boltzmann equation,” Transport Theory and Statistical Physics 30(2 & 3), 205-237 (2001).
3. T. Ohwada, Y. Sone, and K. Aoki, “Numerical analysis of the Poiseuille and thermal transpiration flows between two parallel plates on the basis of the Boltzmann equation for hard-sphere molecules,” Phys. Fluids A 1(12), 2042-2049 (1989).
4. S. Takata, S. Yasuda, S. Kosuge, and K. Aoki, “Numerical analysis of thermal-slip and diffusion-slip flows of a binary mixture of hard-sphere molecular gases,” Phys. Fluids 15(12), 3745-3766 (2003).
5. K. Aoki, Y. Sone, and T. Yamada, “Numerical analysis of gas flows condensing on its plane condensed phase on the basis of kinetic theory,” Phys. Fluids A 2(10), 1867-1878 (1990).
6. K. Aoki, S. Takata, and S. Taguchi, “Vapor flows with evaporation and condensation in the continuum limit: Effect of a trace of noncondensable gas,” Eur. J. Mech., B/Fluids 22(1), 51-71 (2003).
7. K. Aoki, S. Takata, H. Aikawa, and F. Golse, “A rarefied gas flow caused by a discontinuous wall temperature,” Phys. Fluids 13(9), 2645-2661 (2001).
8. S. Taguchi and K. Aoki, “Rarefied gas flow around a sharp edge induced by a temperature field,” J. Fluid Mech. 694, 191-224 (2012).
9. K. Aoki, P. Degond, S. Takata, and H. Yoshida, “Diffusion models for Knudsen compressors,” Phys. Fluids 19(11), 117103:1-21 (2007).
10. K. Aoki, P. Degond, L. Mieussens, S. Takata, and H. Yoshida, “A diffusion model for rarefied flows in curved channels,” Multiscale Model. Simul. 6(4), 1281-1316 (2008).
11. K. Aoki, G. Cavallaro, C. Marchioro, and M. Pulvirenti, “On the motion of a body in thermal equilibrium immersed in a perfect gas,” ESAIM: Math. Model. Numer. Anal. 42(2), 263–275 (2008).