

## **Five Centuries of Turbulence: from da Vinci, to Kolmogorov, to the Universal Log Law**

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Romanticized since Leonardo da Vinci compared the motion of a water jet rapidly falling into a pool to the curls and waves of long, gorgeous hair, turbulence is a field of endeavor blessed with stunning images, elegant mathematics, intellectually fascinating physics, and vitally important applications. Its significance at the human, geologic and cosmologic scales can only be understated. Turbulent transport in plasma sustains the nuclear fusion process that in turn keeps the stars alive; the vigorous turbulent mixing in the atmosphere keeps megacities from suffocating under their own human-produced carbon dioxide; and a turbulent boundary layer allows an airfoil to generate more lift at larger angles of attack than a corresponding laminar flow. The darker facet of turbulence is its extreme complexity, sending chills down the spines of students and professionals alike. Turbulence is also mostly responsible for the high fuel consumption of all air, land and sea transportation systems. Ouch, at today's cost of energy!

In this talk, I shall take a quick passage through five centuries of turbulence research, highlighting the major milestones. The more recent cornerstones include the Kolmogorov's equilibrium theory of turbulence spectrum, the universal logarithmic law of wall-bounded flows, and the proliferation of direct numerical simulations. I shall discuss evidence of recent fault lines in all three major achievements, but also point to novel remedies as well as to a few contemporary accomplishments.

## BIOGRAPHICAL SKETCH

**Mohamed Gad-el-Hak** received his B.Sc. (summa cum laude) in mechanical engineering from Ain Shams University in 1966 and his Ph.D. in fluid mechanics from the Johns Hopkins University in 1973. Gad-el-Hak has since taught and conducted research at the University of Southern California, University of Virginia, University of Notre Dame, Institut National Polytechnique de Grenoble, Université de Poitiers, Friedrich-Alexander-Universität Erlangen-Nürnberg, Technische Universität München and Technische Universität Berlin, and has lectured extensively at seminars in the United States and overseas. Dr. Gad-el-Hak is currently the Inez Caudill Eminent Professor of biomedical engineering and professor of mechanical engineering at Virginia Commonwealth University. From 2002 to 2009, Gad-el-Hak was the chair of mechanical engineering at VCU.

Dr. Gad-el-Hak has published close to 500 articles, authored/edited 18 books and conference proceedings, and presented 280 invited lectures. He is the author of the book *“Flow Control: Passive, Active, and Reactive Flow Management,”* and editor of the books *“Frontiers in Experimental Fluid Mechanics,”* *“Advances in Fluid Mechanics Measurements,”* *“Flow Control: Fundamentals and Practices,”* *“The MEMS Handbook”* (first and second editions), *“Transition and Turbulence Control,”* and *“Large-Scale Disasters: Prediction, Control and Mitigation.”*

Professor Gad-el-Hak is a fellow of the American Association for the Advancement of Science, the American Physical Society, the American Society of Mechanical Engineers, and the American Academy of Mechanics.

In 1998, Professor Gad-el-Hak was named the Fourteenth ASME Freeman Scholar. In 1999, Gad-el-Hak was awarded the prestigious Alexander von Humboldt Prize, Germany’s highest research award for senior U.S. scientists and scholars in all disciplines. In 2002, Gad-el-Hak was named ASME Distinguished Lecturer, as well as inducted into the Johns Hopkins University Society of Scholars.