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

Mohamed Gad-el-Hak
The Inez Caudill Eminent Professor
Department of Mechanical & Nuclear Engineering
Virginia Commonwealth University
Richmond, Virginia
U.S.A.
<gadelhak@vcu.edu>

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.