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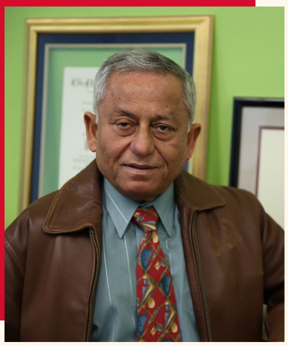
Some Extensions of Our Vortex Dynamics and Turbulence Research Done at UH



Fazle Hussain

Department of Mechanical Engineering,
Texas Tech University

ABSTRACT:

Turbulence and vortex dynamics, explored during Hussain's long tenure at UH, is being further researched. Some new results in vortex core dynamics, vortex-turbulence interaction and vortex breakdown are reviewed along with a detailed discussion of vortex reconnection (VR). VR is a fundamental topology transforming dynamical event of major significance in turbulence phenomena such as cascade, fine-scale mixing, and aerodynamic noise generation. In addition to its physical relevance, VR is also a stand-alone mathematical problem in studying finite time singularity of the Euler equation. Hence, VR has been extensively studied recently, both in classical and in quantum turbulence. We first summarize our prior (UH) results on viscous VR (mainly at low Reynolds numbers, Re = circulation/viscosity), including its physical mechanism, scaling, effects of polarization and compressibility, etc. Our recent direct numerical simulation of VR up to Re = 40,000 shows the first evidence of VR cascade scenario as the physical mechanism of turbulence cascade initially proposed by Melander & Hussain (1988, CTR Reports, Stanford U.), who suggested that the remnant threads undergo VR in a reconnection cascade As Re increases, higher (e.g., third) generation of VR is seen, and the energy rapidly avalanches to a turbulent cloud of slender rings and hairpins - having a -5/3 spectrum. These results confirm our long-standing claim that VR is important in the elusive physical mechanism of turbulence cascade. In addition, we address the helicity dynamics involved in VR occurring in evolutions of a trefoil knotted vortex and a Hopf-link. For both cases, the global helicity H sharply increases during VR, and the growth rate increases with increasing Re – suggesting that H for viscous flows is not conserved as $Re \to \infty$.

BIOGRAPHY:

Fazle Hussain's expertise is in vortex dynamics, turbulence, coherent structures, and measurement techniques, and is most known for his students' experiments and numerical analyses in fluid turbulence. He has also researched in solar energy, holography, flow noise, flow control, cardiovascular dynamics, and nanotechnology. He is now interested in drag reduction, wind turbine technology, , cancer cell mechanics, and food production on Mars. Following his PhD in mechanical engineering in 1969 at Stanford, he was a post-doc at Johns Hopkins, before joining UH, where he became professor in 1976, Cullen Distinguished Professor in 1989, and Cullen Distinguished University Chair in 2010. He joined Texas Tech University in 2013 as the President's Endowed Distinguished Chair in Engineering, Science & Medicine. He has been recognized with the four topmost awards in fluid mechanics: the Fluid Dynamics Prize (1998) of the American Physical Society (APS), the Freeman Scholar Award (1984) and the Fluids Engineering Award (2000) of ASME, and the Fluid Dynamics Award (2002) of AIAA. He served as the Chair of the Fluid Dynamics Division of APS, Chair of ME of NAE, and is a Fellow of APS, ASME and AIAA. He served as a Board Member of TAMEST and was a former recipient of UH's Farfel Award. He was 2009 Moore Distinguished Scholar at Caltech (concurrently with Stephen Hawkings), and is an Honorary Professor (for Life) at the Peking University (Beijing). Jeong &Hussain (1995), published at UH, is the highest cited paper in the J. of Fluid Mechanics.