Turbulent Jets

Joseph Mathew

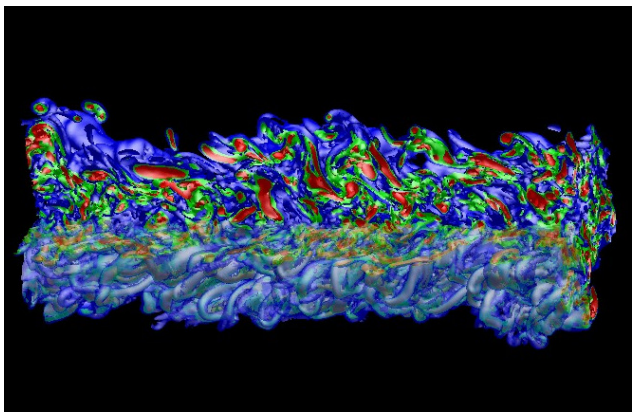
Department of Aerospace Engineering, Indian Institute of Science, Bangalore 560012 INDIA

Email address for correspondence: joseph@iisc.ac.in

Abstract

Jets are canonical flows that have been the subject of many studies. Jets appear in many applications while also serving as a model for many kinds of fundamental studies. A round jet emerging from a nozzle can be viewed as a nearly uniform flow bounded by a thin cylindrical shear layer. This shear layer is susceptible to Kelvin-Helmholtz-like instability resulting in a wavy appearance that develops into a train of vortex rings. These rings undergo an azimuthal (Widnall) instability, and then a rapid breakdown, over a distance much smaller than jet diameter, into a turbulent round jet. Our complete viscous instability analysis of vortex rings, and tracking the linear growth of unstable modes ending in nonlinear processes, revealed the reasons for the very rapid breakdown. The turbulent jet is a canonical example of a self-preserving flow. It was the setting for our new understanding of turbulent entrainment. Essential principles for large eddy simulations were clarified by our studies of jets at very high Reynolds numbers, performed with a less widely known method that we had proposed at the beginning of this century. Examples from our studies will be presented, including some new phenomena in supersonic jets and scaling in twin jets.

Keywords: Instability, Transition, Large eddy simulation



Acknowledgments

I thank my students and collaborators from India and abroad who helped me get a better understanding of turbulent flows and numerical methods for their prediction. Much of the fundamental studies were supported by my employer, the CSIR-NAL, initially, and the Indian Institute of Science. I thank 18 ACFM for this invitation to present results from a most satisfying part of my research.