Institute Lecture

Simulation Enabled Discoveries: Examples from MHD and Turbulence

Prof. Ravi Samtaney,

Professor, Mechanical Engineering,

King Abdullah University of Science and Technology (KAUST)

10th February 2016, Time: 6 PM, Venue: L-5

Abstract

Computation has emerged as the indispensable third leg of scientific discovery along with the traditional two branches of theory and experiment. In this talk we discuss some case studies from magnetohydrodynamics (MHD) and fluid turbulence.

Our first example is that of magnetic suppression of the Richtmyer-Meshkov instability (RMI). In hydrodynamics, a density interface separating two fluids is unstable under impulsive acceleration. This instability aka RMI has been the bane of inertial confinement fusion where it is considered highly detrimental. We present a vortex dynamical interpretation of the instability and show that, in MHD, the baroclinic vorticity generated on the interface is carried away by slow-mode MHD shocks leading to stabilization.

The second example is that of magnetic reconnection (MR). Loosely defined, MR is the breaking and reattachment of magnetic field lines, and is a somewhat ubiquitous phenomenon in our universe: it accompanies coronal mass ejections from our Sun, observed in the earth's magneto-tail, etc. Standard quasi-steady models in single-fluid resistive MHD severely under-predict the reconnection rate compared with observations. A key missing piece of physics is an instability dubbed the plasmoid instability. Large-scale simulations led to the discovery that for Lundquist number greater than 10^4, the reconnection rate saturates due to plasmoids.

A third example pertains to the question whether the mean velocity profile in a wall-bounded turbulence obeys a log-law or a power-law. Our simulations results provide strong evidence that turbulence gravitates naturally towards the log-law scaling at extremely large Reynolds numbers.

We believe these case studies amply demonstrate that simulation enabled discoveries are no longer a myth, and that computations are a legitimate tool to answer clearly posed questions in science and engineering.

About the speaker

Prof. Ravi Samtaney is a Professor of Mechanical Engineering within the Physical Sciences and Engineering Division (PSE), with a secondary appointment in applied mathematics at the King Abdullah University of Science and Technology in Saudi Arabia. He also serves as the Associate Dean of the PSE Division. He joined KAUST in 2010. Prior to joining KAUST, Prof. Samtaney was a research physicist in the Theory Department of the Princeton Plasma Physics Laboratory, Princeton University. Previously, he held the position of senior research associate in the Aeronautics, and Applied & Computational Mathematics at Caltech. His professional experience includes working as a research scientist at NASA Ames Research Center. Prof. Samtaney holds a Ph.D. from Rutgers University in Mechanical & Aerospace Engineering.

Prof. Samtaney's main area of expertise is in computational physics of fluids and plasmas, numerical methods, and high-performance computing.

Tea at 5:45 PM

All interested are welcome.

Amalendu Chandra
Dean of Research and Development, IIT Kanpur