Seminar

Institute for Plasma Research

Title : Turbulence, flows and magnetic field generation in plasmas using a magnetohydrodynamic model

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Date : 29th March 2019 (Friday)

Time : 10.30 AM

Venue : Board Room, New Building, IPR

Abstract :

Understanding plasma turbulence is key to control the disruption of plasma in experimental devices thereby improving the confinement of plasma as well as predicting extreme events occuring in astrophysical objects and stellar matter. One of the best suited models to explain various large or intermediate scale events in plasma is magnetohydrodynamics (MHD). The magnetic field-lines coupled with the plasma flow offer completely new dynamics and energy transfer mechanism between modes. To understand such new mechanism “direct numerical simulation” (DNS) study of MHD equations is very necessary.

In order to carefully observe the energy cascades through different modes, a MPI parallelised three dimensional pseudo-spectral DNS code, G-MHD3D, has been developed from scratch that governs the dynamics of plasma within the framework of single fluid MHD. In collaboration with NVIDIA, India, the code has been GPU parallelised and multi-GPU parallelisation using NVLink has recently been achieved.

In the presence of weak resistivity, the MHD model is known to predict irreversible conversion of magnetic energy into fluid kinetic energy (i.e. reconnection) as well as conversion of kinetic energy into mean large scale magnetic field (i.e. dynamo). Therefore it is interesting to ask oneself, can there be a nearly “reversible” process in the form of coherent nonlinear oscillations that cycle the energy back and forth between the magnetic and kinetic form. In this work, the existence of such large amplitude oscillations for a wide range of initial flow speeds or Alfven Mach numbers has been reported. The oscillations are identified as nonlinear dispersionless Alfven waves.

For three dimensional chaotic flows at Alfven resonance, a detailed DNS study has been performed using G-MHD3D and it is found that for two different initial conditions, one flow reconstructs the initial fluid and magnetic flow profile and the other does not. The phenomena is called as “Recurrence”. Unlike hydrodynamic systems, in MHD system, the energy oscillates between kinetic and magnetic modes thereby periodically destroying and reconstructing back the structures of the field variables.

Finally the driven dissipative systems are studied at very high Alfven Mach number leading to self-consistent stretch-twist-fold (STF) dynamo effect showing short scale magnetic field generation from kinetic energy. Starting with Arnold-Beltrami-Childress (ABC) driven flow, optimal parameters for “fast” dynamo are also obtained.

In this presentation, several of the above said results will be discussed along with major current challenges and possible future directions.