Wednesday, Nov. 16: morning

Drift Wave-Zonal Flow Turbulence with Magnetic Coupling

Pat Diamond
WCI Fusion Theory Center, National Fusion Research Institute, Korea / Univ. of San Diego, USA

Wednesday, Nov. 16: morning

Nonlinear drive of linearly damped modes by phase-space tructures

Maxime Lesur
WCI Fusion Theory Center, National Fusion Research Institute, Daejeon, Korea

The nonlinear interactions between plasma waves and particles is a topic with applications in usion devices for the diagnostic and mitigation of confinement-threatening instabilities, and the ontrolled amplification of favorable modes, as well as in astrophysics for the understanding of osmic rays. A simple 1D kinetic model captures the essential nonlinearities (particle trapping, eneration and evolution of phase-space structures) by retaining a key ingredient: damping of he wave by dissipative processes.
In this work, we use this toy model to develop a new theory for the generation of phase-space tructures, which shows that they can drive instabilities in a regime where linear theory predicts hat the mode should be stable. Our simulations confirm the validity of this theory.

Wednesday, Nov. 16: morning

Momentum Transport and Self-Acceleration in Tokamak Plasmas

Jae-Min Kwon

WCI Fusion Theory Center, National Fusion Research Institute, Daejeon, Korea

Wednesday, Nov. 16: morning

Intrinsic Rotation and Dynamics of Internal Transport Barriers with Reversed Magnetic Shear in Tokamaks

Hogun Jhang[1], S. S. Kim[1], P. H. Diamond[1,2]

[1]WCI Fusion Theory Center, National Fusion Research Institute, Daejeon, Korea

[2]CMTFO and CASS, Univ. of San Diego, CA, USA

Realization of advanced tokamak operation in ITER requires operating a plasma in enhanced confinement regime, likely characterized by the existence of core transport barrier. This is re-kindling interest in internal transport barrier (ITB) dynamics at zero or low external torque. Recent global gyrofluid simulations have clearly shown that intrinsic rotation (i.e. self-acceleration of a magnetically confined plasma) is strongly coupled to torque-free ITB dynamics (i.e. forward and back transition) in reversed shear plasmas[1], featuring unique properties of ITB hysteresis. In this presentation, we (1) present results of gyrofluid simulations on the generation of intrinsic rotation in ITB plasmas and (2) give a detailed analysis of the interplay between intrinsic rotation and ITB dynamics and investigate the role of parallel-shear-flow-driven instability (PSFI) in ITB formation and back transition.

In the power ramp simulation, several peaks in $<dV_{||}^2>$ are observed when the ExB shearing rate at the region of maximal $\nabla V_{||}$ is below the linear growth rate, which implies the excitation of PSFI. The PSFI onset is followed by a Reynolds stress change and drives a momentum redistribution which significantly affects the radial profile of $\nabla V_{||}$ near the q_{min} position. This plays an important role in ITB dynamics since the ExB shearing rate closely tracks ▽V|| at qmin position. Reynolds stress burst (RSB) appears after the PSFI and induces an outward momentum transport event (MTE) during power ramp down. The outward MTE finally gives rise to the reduction of both mean and zonal flow shears, which triggers barrier back transition. Other interesting findings such as nonlocal interaction between fluctuations at different position will be discussed at the workshop.

[1] S. S. Kim, Hogun Jhang, P. H. Diamond, et. al., Nucl. Fusion, **51** (2011) 073021

Wednesday, Nov. 16: afternoon

Physics of Hydrodynamic Turbulence and Passive Scalar Transfer

Toshiyuki Gotoh
Nagoya Institute of Technology, Japan

Fundamental problems in statistical physics of hydrodynamic turbulence and scalar transfer are reviewed. Kolmogorov and Obukhov-Corrsin phenomenology for turbulence and scalar fluctuation are shortly explained and a brief sketch of the spectral theory are examined. Then we consider the intermittency and universality at small scales of motion, which are one of the fundamental issues of turbulence physics. Recent progress and results from very large scale direct numerical simulations are described, and finally the future direction for the research is argued.

Wednesday, Nov. 16: afternoon

PIC Simulation Study of Nonlinear Interaction and Turbulence Driven Parametric Instability of the AIC (Alfven ion-cyclotron) Waves

Chang-Mo Ryu
Dept. of Physics, Postech, Korea

Wednesday, Nov. 16: afternoon

Weak and Strong Hall / MHD Turbulence in Solar Physics

Sebastien Galtier
IAS, bâtiment 121, Université Paris-Sud, France

Wednesday, Nov. 16: afternoon

Alfvenic Turbulence in Future Large Scale Fusion Plasmas

T. S. Hahm
Seoul National University, Korea

Wednesday, Nov. 16: afternoon

Scaling Relations of MHD and EMHD Turbulence

Jungyeon Cho
Chungnam National University, Korea

Thursday, Nov. 17: morning

It only Takes a Small Amount of Helicity to Have a Large-Scale Dynamo

Annick Pouquet
NCAR, USA

We revisit the role played in the growth and saturation of large-scale magnetic fields by the relative amount of kinetic helicity in the imposed forcing of a flow, varying the scale separation between the largest-scale accessible mode and the scale of the forcing. To that effect, we use direct numerical simulations of the MHD equations at fixed magnetic Prandtl number, $P_M=4$, and with variable resolutions and forcing scales. We find that the more the scale separation between forcing and the overall size of the box, the easier it is to obtain a large-scale dynamo at a given imposed rate of relative kinetic helicity f_h. For a scale separation of 6, such a large-scale dynamo obtains for $f_h < 1\%$. We also confirm the central role played by the interplay between the kinetic and magnetic helicity and their relative values at small and at large scale.

With Jonathan Pietarila Graham, Eric G. Blackman and Pablo D. Mininni

Thursday, Nov. 17: morning

Basic MHD Turbulence and Small-Scale Dynamo

Andrey Beresnyak
University of Bochum, Germany

MHD dynamo, a growth of magnetic field in a conductive fluid, is important in all areas of astrophysics and plasma physics. We consider dynamo in a turbulent medium with asymptotically large Reynolds numbers (Re). Based on our rigorous locality bounds we claim that magnetic energy grows at a rate which is a constant fraction C_E of the total turbulent dissipation rate. This dimensionless "efficiency of small-scale dynamo", C_E, is a true constant for large Re and is determined only by strongly nonlinear dynamics at the equipartition scale. Numerical simulations show C_E around 0.05. Below equipartition scale for kinetic and magnetic energies the spectrum is steep (Kolmogorov's -5/3) and is represented by critically balanced strong MHD turbulence. Near the sources of perturbation, such as the Sun in solar wind or the central engine in jets, MHD turbulence is often imbalanced or cross-helical. The keys to understand energy cascades in the imbalanced case are the anisotropies of the Elsasser fields which are notably different. I will outline a predictions of the model and compare them with simulation results.

Thursday, Nov. 17: morning

Magnetic Helicity and the Rapid Growth of Large Scale Magnetic Fields

Ethan Vishniac
University of McMaster, Canada

I show that turbulence in a differentially rotating object drives a flux of magnetic helicity along the spin axis even in the absence of any large scale magnetic fields. The resulting dynamo is never kinematic and drives a large scale field super-exponentially. The dynamo saturates when the magnetic field is strong enough to inhibit the magnetic helicity flux. Using a simple model for turbulence in a galactic disk I predict that the time required to produce large scale magnetic fields with observed strengths is only a few rotation periods. No significant seed fields are required.

Thursday, Nov. 17: morning

Turbulent Dynamos in Astrophysics: Problems and Prospects

Kandaswamy Subramanian
IUCAA, India

Magnetic fields and turbulence are ubiquitous in the universe. Here we review the turbulent dynamo generation of astrophysical magnetic fields focusing on galactic and galaxy cluster magnetism. Fluctuation dynamos will be crucial to understand magnetic fields in clusters and young galaxies. Mean field dynamos are required to understand observations of present day disk galaxies. The major concern is how coherent are the generated fields, especially as the dynamo saturates. The importance of magnetic helicity fluxes in understanding mean field dynamos is emphasized.

Thursday, Nov. 17: afternoon

Interstellar Turbulence: Effects of Compressibility, Magnetization, and Gravity

Alexei Kritsuk
University of California - San Diego, USA

Thursday, Nov. 17: afternoon

Mean-structure–Turbulence Interaction in Magnetic Reconnection

Nobumitsu Yokoi
University of Tokyo, Japan

Effects of turbulence are investigated in the context of magnetic reconnection. Primary effect of turbulence is enhancing the effective transport (mixing, magnetic-field diffusion, etc.). However, breakage of symmetry in turbulence may contribute to the suppression of turbulent transports. By considering interactions between the mean-field inhomogeneous structures and turbulence, properties of turbulent transport in magnetic reconnection are examined. It is shown that the cross helicity in turbulence modulates the mean-field configurations. As this consequence, the reconnection region is confined to a tiny region, leading to a high reconnection rate.

Thursday, Nov. 17: afternoon

Mach Number Dependence of the Turbulent Dynamo: Solenoidal vs. Compressive Flows

Christoph Federrath
University of Heidelberg, Germany

We study the growth rate and saturation level of the turbulent dynamo in magnetohydrodynamical simulations of turbulence, driven with solenoidal (divergence-free) or compressive (curl-free) forcing. For models with Mach numbers ranging from 0.02 to 20, we find significantly different magnetic field geometries, amplification rates, and saturation levels, decreasing strongly at the transition from subsonic to supersonic flows, due to the development of shocks. Both extreme types of turbulent forcing drive the dynamo, but solenoidal forcing is more efficient, because it produces more vorticity. (PRL, in press)

Thursday, Nov. 17: afternoon

Weak Field Amplification in Moderately Compressible MHD Turbulence

Tom Jones
University of Minnesota, USA

Numerical models of driven, compressible, and isothermal MHD turbulence are being used to study the growth and saturation of magnetic fields in environments similar to galaxy cluster media. Simulations in periodic boxes with initially very weak magnetic fields
are stirred randomly on large scales to establish turbulent motions that stretch and amplify the seed field. The driving kick is decomposed into sheared (solenoidal) and compressional contributions, and the fractions of these contributions are varied among the simulations in order to explore the dependence of the turbulence properties on this character of the driving. The simulations are continued into approximate equilibrium.
The focus of this presentation is the evolution of the magnetic field energy and distribution as well as the properties of solenoidal and compressional motions in saturation and how these depend on the character of the driving motions.
This work is supported by the US National Science Foundation, the National Research Council of Korea and the Minnesota Supercomputing Institute.

Thursday, Nov. 17: afternoon

Structures in Compressible MHD Turbulence

David Porter
University of Minnesota, USA

Numerical models of driven, compressible, and isothermal magneto-hydrodynamic turbulence are used to study grown and saturation of magnetic fields in the inter-galactic medium in clusters of galaxies. Models start with extremely week magnetic field ($\beta_{initial}=10^6$), are periodic in all three dimensions, and are continuously stirred on the longest length scales. The strength of velocity driving is calibrated to generate flows with RMS Mach number of about 0.5 in equilibrium. These models go though a phase of fully developed neutral fluid turbulence before the magnetic field is strong enough to significantly modify the flow. However, over time the magnetic field builds until beta is of order ten and the flow is greatly modified.
The focus of this presentation is to compare configuration space structures between the neutral fluid and magnetically saturated phases of these flows. We, there-by, hope to characterize the influence of magnetic fields on flows in the ICM. Mesh resolution as high as 2048^3 is used to resolve structures well below the scales on which the flow is directly driven. While velocity gradients are dominated by vortex tubes in the early "neutral fluid" phase, sheets and strips of both shear and magnetic field are observed in the late "magnetically saturated" phase of the flow. Laminated structures, with multiple, thin, and nearly parallel layers velocity shear and magnetic field are seen in the magnetically saturated phase of the flow. These structures are seen to fill most of the volume at late times. Visualization of these structures are used to motivate new statistical measures, which quantify the growth, saturation, and dynamical importance of these laminated structures in low-beta MHD turbulence.
This work is supported by the US National Science Foundation, the Minnesota Supercomputing Institute, and the National Research Council of Korea.

Thursday, Nov. 17: afternoon

Statistical Properties of Supersonic Turbulence in the Lagrangian and Eulerian Frameworks

Lukas Konstandin

University of Heidelberg, Germany

We present a systematic study of the influence of different forcing types on the statistical properties of supersonic, isothermal turbulence in both the Lagrangian and Eulerian frameworks. We analyse a series of high-resolution, hydrodynamical grid simulations with Lagrangian tracer particles and examine the effects of solenoidal (divergence-free) and compressive (curl-free) forcing on structure functions, their scaling exponents, and the probability density functions of the gas density. Compressively driven
simulations show a significantly larger density contrast and a more intermittent behaviour. We show that the absolute values of Lagrangian and Eulerian structure functions of all orders in the integral range are only a function of the root mean square Mach number, but independent of the forcing.

Friday, Nov. 18: morning

Turbulence in Intracluster Media

Dongsu Ryu

Chungnam National University, Korea

Turbulence is ubiquitous in astrophysical environments. I will briefly summarize its characteristics, focusing on the turbulence in the intergalactic medium.

Friday, Nov. 18: morning

Phase Transition Dynamics of Multi-Phase Interstellar Medium

Shu-ichiro Inutsuka
Nagoya University, Japan

Gas dynamics of interstellar medium is remarkably different from that of simple barotropic gas owing to the phase transitions between cold phase and warm phase (and hot phase) that trigger variety of instabilities. Identifications of distinct instabilities in various stages provide us important clues for understanding the saturation levels of turbulent energies and rates of formation and destruction of cold clouds, etc. Recent progress in this line of theoretical work is reviewed and future direction will be outlined.

Friday, Nov. 18: morning

The Nature of Molecular Cloud Turbulence

Enrique Vazquez-Semadeni
UNAM, Mexico

Friday, Nov. 18: morning

B-field Strength Estimation of the Warm Ionized Medium Based on a Distribution of Faraday Rotation Measures

Jongsoo Kim
Korea Astronomy & Space Science Institute (KASI), Korea

We propose a new method to measure magnetic field strength based only on a distribution of Faraday rotation measures of a patchy of the warm ionized medium located in front of a polarized background. For this purpose we performed nine isothermal, magnetohydrodynamic turbulence simulations. The root-mean-square Mach numbers of turbulent flows at a converged state are subsonic, transonic, and mildly supersonic, and initial plasma beta values are 0.1, 1, and 10. Those ranges of parameters cover the observed values of the warm ionized medium. Our main results are as follows. (1) There is no strong correlation between the fluctuations of magnetic field strength and gas density. So the magnetic field strength estimated with the ratio of rotation measure to dispersion measure along a line-of-sight correctly provides us with the true averaged field strength. (2) A histogram of rotation measures is well fitted with the Gaussian distribution. Furthermore, there is a good correlation between the width of the histogram and the regular field strength along the line-of-sight; the narrower the width, the stronger the field strength. As an application of our method, we show that the estimations of field strength in Auriga and Horologium regions (Haverkorn et al. 2003, 2004) based on our correlation are consistent with their measurements.

Friday, Nov. 18: afternoon

Turbulence, Cosmic Rays and Reacceleration in direct Cluster Simulations

Julius Donnert
MPA-Garching, Germany / INAF, Italy

Radio Halos are Mpc sized diffuse objects commonly found in merging clusters. Their size poses the problem on maintaining a cluster-wide CR electron population, while its injection from shock and galacitic outflows is localised. In Reacceleration models merger injected MHD turbulence couples to the transrelativistic CRe population via transit-time-damping and leads to momentum diffusion of the CRe to synchrotron bright momenta. These models are predicted to elegantly solve many problems encountered with other approaches, at the cost of increased complexity.
We use a model for local turbulence in SPH and a novel implementation of a Fokker-Planck solver to follow the reacceleration of CR electrons by turbulence in postprocessing to a direct simulation of a cluster merger. We use hadronic injection of CR electrons to seed the population. We find that this mechanism does not only produce a bimodality, but also gives broken radio spectra and CR proton densities compatible with recent gamma-ray observations.

Friday, Nov. 18: afternoon

Turbulence-driven Accretion Flows

Ilya Kovalenko
Volgograd State University, Russia

The quasi-spherical accretion of gas onto a black hole is a striking example of gasdynamical flow when turbulence not only plays the role of a transport mechanism but also exerts direct force action on dynamics. By developing an approximate analytical model we show that turbulence acts as a source of a centrifugal force effectively preventing from intensive accretion. The model is based on a first-principles approach and utilizes minimum of arbitrary hypotheses.
Basic assumptions used are

- suggestion of moderate turbulent pulsations (weakly nonlinear model),
- spherical symmetry upon the average,
- assumption of smallness of correlators "pressure-velocity" compared to "dynamical pressure-velocity".

We find that turbulence restructures the character of quasi-stationary flow essentially compared to the laminar Bondi accretion owing to generation of non-zero specific angular momentum. For a pseudo-Newtonian potential we found that turbulent quasi-spherical flow can have double transonic transition which allows to get a solution with a standing spherical shock wave.
Numerical simulations of quasi-spherical accretion were fulfilled in two series of tests: 2D axially symmetrical flows within sphere and within figure complementing cone and 3D flow without preconditioned symmetry. Summarizing results, we observe two kinds of possible behavior. For turbulent perturbations with relative amplitude $\lesssim$ 0.5 the vortex structure is poorly defined and the basic part of turbulent pulsations energy is concentrated in acoustic perturbations manifesting themselves through the system of shock fronts encircling the computational domain and forming cellular-type structure with a typical length of a shock segment equal to radius. Such a structure is not stable and tends to be diluted within several tens of dynamical times. For a supersonic turbulence with large relative amplitudes > 0.5 the well-pronounced vortex structure is formed, accretion inflow slows down and the flow becomes essentially subsonic one. In tote, the characteristics of flow in numerical models are in good qualitative accord with analytical predictions except the fact that the flow with a steady state spherical shock has never been discovered.
The considered model may pertain to the problem of gap in detection of black holes with intermediate masses. Their rare registration can be related with the phenomenon of radiative inefficiency of accretion flow (RIAF). The simplest RIAF model is the spherical Bondi accretion model. However, it disagrees with observations, in particular, it is considered that the real rate of accretion in isolated black hole should be significantly less than the Bondi's one.

Friday, Nov. 18: afternoon

Turbulence in Expanding and Contracting Media

Junsung Park
Chungnam National University, Korea

We investigate decaying magnetohydrodynamic (MHD) turbulence by including the effects of expansion and contraction of the background medium. The problem has two time scales, the eddy turn-over time(t_{eddy}) and the expansion/contraction time scale($t_{exp-cntr}$). The turbulence is expected to behave differently in two regimes of $t_{eddy} < t_{exp-cntr}$ and $t_{eddy} > t_{exp-cntr}$. For instance, for $t_{eddy} < t_{exp-cntr}$, the turbulence would decay more or less as in a static medium. On the other hand, for $t_{eddy} > t_{exp-cntr}$, the effects of expansion and contraction would be dominant. We examine the properties of turbulence in the regimes of $t_{eddy} < t_{exp-cntr}$ and $t_{eddy} > t_{exp-cntr}$. Based on it, we derive a scaling for the time evolution of flow velocity and magnetic field.

Friday, Nov. 18: afternoon

Inverse Energy Cascade in Driven 3D EMHD Turbulence

Hoonkyu Kim
Chungnam National University, Korea

We present numerical simulations of inverse energy cascade and in driven three-dimensional (3D) electron magnetohydrodynamic (EMHD) turbulence. It has been known that inverse energy cascade only occurs in two-dimensional (2D) turbulence. However, we demonstrate that inverse energy cascade occurs in driven 3D EMHD turbulence. When magnetic helicity is injected on a small-scale, magnetic energy goes up to larger scales. The energy spectrum clearly shows inverse energy cascade. At the same time, magnetic helicity spectrum also shows that the helicity goes up to larger scales. We obviously confirm inverse energy cascade. Net magnetic helicity for scales larger than the driving scale shows linear growth, and magnetic energy shows non-linear growth. On the other hand, when we drive turbulence without magnetic helicity, we do not observe inverse energy cascade.

Friday, Nov. 18: afternoon

Magnetic Reconnection, Helicity Dynamics and Hyper-resistivity

Zhibin Guo
WCI Fusion Theory Center, National Fusion Research Institute, Daejeon, Korea

In this talk, we'll study the noisy reconnection problem.

Friday, Nov. 18: afternoon

Hydrodynamical Instabilities of a Supernova Blast Wave at the Sedov Stage

Andrey Zankovich
Volgograd State University, Russia

This work presents in a sense a sequel of research by Ryu and Vishniac (1987-1991) who studied stability of adiabatic spherical shock against self-excited oscillations.
We instead analyze stability of adiabatic spherical shock against forced oscillations when shock propagates into an ambient medium with small inhomogeneities. Medium consists of the uniform background on which small perturbations of velocity or density are imposed. These mimic the influence of turbulent motion or clouds segregation in the interstellar medium on the dynamics of supernova remnant at the adiabatic Sedov stage.
We show by linear analysis and 2D hydrodynamical modeling that the shock wave is subject to resonant amplification of certain spherical harmonics in both cases. The instability found can bring to both rapid star formation and turbulization of interstellar gas. We present an original method of visualization of turbulent characteristics of flow behind the shock front via the hodograph of velocities.

Friday, Nov. 18: afternoon

Compressible hydrodynamics turbulence

Supratik Banerjee
IAS, bâtiment 121, Université Paris-Sud, France

Saturday Nov. 19: morning

Stochastic Acceleration by Turbulence and Solar Flares

Vahe Petrosian
Stanford University, USA

Saturday Nov. 19: morning

Particle Acceleration by MHD Turbulence in Galaxy Clusters : Models and Constraints from Radio and High Energy Observations

Gianfranco Brunetti
Istituto di Radioastronomia - INAF, Italy

Saturday Nov. 19: morning

Turbulent Acceleration of Charged Particles in Space

Peter Yoon
IPST, University of Maryland, USA / SSR, Kyung Hee Univ, Korea

The acceleration of charged particles in space is a fundamental problem. Charged particle acceleration by plasma turbulence may be a ubiquitous phenomenon in the Universe. In the present talk I shall outline the Vlasov kinetic theory of plasma turbulence and how the theory can be used to explain the charged particle acceleration in space. For the electrons, it will be shown that the interaction of high-frequency Langmuir turbulence leads to the high-energy power-law tail distribution, and the theory will be compared against the observation made at 1AU. For the ions, the low-frequency Alfvenic turbulence must be involved in the particle acceleration process. However, MHD turbulence theory has no wave-particle resonance, so the heating can only be inferred. Reduced theories, such as the gyrokinetic theory, have no cyclotron resonance. I shall outline an ongoing effort to bring the current state of knowledge to fully kinetic Vlasov turbulence theory in magnetized plasmas.

Saturday Nov. 19: morning

Cosmic Ray Transport and Gamma Ray Emission from SNRs

Huirong Yan
KIAA, Peking University, China