391S Fall 2023, Plasma Seminars (NLD too)

Instructor: P. J. Morrison

Aug. 29: Norman Cao, IFS UT-Austin
Title: *Order and Chaos in Turbulent Geophysical and Plasma Flows*

Sept. 5: Cole Stephens, IFS UT-Austin
Title: *Introduction to Gyrokinetic Theory*
Abstract:
Gyrokinetics is a fundamental tool to study turbulence and transport in magnetized plasmas, such as fusion or astrophysical plasmas. The exact kinetic modeling of these systems is difficult due to the large phase space and multiscale nature of the problem. Here, we exploit the wide separation in spatial and temporal scales in such systems to construct an adiabatic invariant of motion of single-particle motion, the magnetic moment. By using the Lie transform, we derive a near-identity non-canonical transformation that ensures both magnetic moment conservation and the preservation of the Hamiltonian structure of the single-particle system. This new set of coordinates describes the drift motion of particle gyrocenters where the fast cyclotron motion has effectively been averaged out. With this set of coordinates in hand, we then construct the gyrokinetic equation, leading to greatly simplified dynamics and a reduction in the phase space.

Sept. 12: Kayman J. Gonçalves, State University of Campinas, Brazil
Title: *Polarization of vector mesons in non-equilibrium hydrodynamics with spin*
Abstract:
One of the most interesting developments in the investigation of quark-gluon plasma was the discovery that the vorticose fluid created in heavy ion collisions polarizes Lambda baryons and aligns spin of quarkonia (bound quark-antiquark states) and vector mesons [1]. This opened a new deep field of investigation, since the interaction of spin and vorticity in systems close to local equilibrium is not understood even on a conceptual level. Here, we argue that spin alignment of hadrons of spin 1 and higher provide a unique window into the study of hydrodynamics with spin, because it is capable to probe non-equilibrium between spin density and vorticity. This happens because most of the full 3X3 density matrix is in principle accessible experimentally, and non-zero off-diagonal matrix elements can be directly linked to such non-equilibrium. We illustrate this using a coalescence model for light vector mesons [2] as well as a potential model for quarkonia, and compare our calculations to experimental data [3].

[1] F Becattini, M. Lisa, 2003.03640

[2] Kayman J. Gonçalves, Giorgio Torrieri, Phys.Rev.C 105 (2022) 3, 034913, e-Print: 2104.12941

[3] Paulo de Moura, Kayman J. Gonçalves, Giorgio Torrieri 2305.02428

Sept. 18: Yoshi Kimura, Nagoya University, Japan

Title: *Vortex reconnection as a candidate for a finite time singularity of the Navier-Stokes equations*

Abstract:

Regularity/Singularity of the Navier-Stokes equations is one of the 7 millennium prize problems of the Clay Mathematical Institute. As a candidate for the solutions to that problem, vortex collisions, or eventual vortex reconnections have been investigated widely. Recently, a dynamical system is proposed which describes a vortex reconnection of two vortex rings located symmetrically on two tilted planes initially. In this talk, after showing the introduction of the problem, we will present some results of analysis and simulations of the dynamical system.

Sept. 19: Carlos Gonzalez, UT Austin

Title: *Local proton heating at magnetic discontinuities in the Alfvénic and non-Alfvénic solar wind*

Abstract:

Understanding how the solar wind is heated while it expands in the inner heliosphere remains an open fundamental question. Plasma temperature enhancements have been commonly associated with intermittent structures or magnetic discontinuities. However, solar wind streams differ by the type of fluctuations and turbulence, and which mechanism that lead to proton heating are favored in different solar wind conditions remains to be understood. Here we investigate local proton energization at magnetic structures/discontinuities and the corresponding kinetic signatures in velocity phase space in Alfvénic (high cross helicity) and non-Alfvénic (low cross helicity) wind, by using Parker Solar Probe observations at distances $0.07 < R < 0.263$ AU. We complement our data analysis with 2.5 hybrid-kinetic simulations to understand what processes are likely to contribute to the observed proton heating and temperature anisotropy in the two types of wind. We compare the local kinetic features and temperature enhancements found in Alfvénic and non-Alfvénic streams and discuss to what extent they can be explained in terms of wave-like vs 2D turbulence dynamics.

Sept. 26: Swadesh Mahajan, IFS UT Austin

Title: *Resonantly interacting quantum plus classical waves*

Abstract:

Dynamics of electrons subjected to a constant amplitude classical electromagnetic (EM) wave is investigated as a fundamental, representative problem in the physics of interacting quantum and classical waves. In the nonrelativistic regime (electrons as Schrödinger waves), the electron energy acquires a constant and a time dependent part. Driven by EM waves, both parts scale strongly with the amplitude, but we expect no resonant enhancement since the parallel electron "speed" of nonrelativistic electrons could never match the wave phase velocity. In the relativistic regime (electron as a Klein–Gordon wave), however, a class of electron waves (with parallel speed matching the EM phase speed) are resonantly excited to extremely high energies. Such a direct resonant energy transfer from intense electromagnetic waves constitutes a mechanism that could, in principle, power the most energetic of cosmic rays (this mechanism will work on protons just as well). Some predictions of the theory will, hopefully, be tested in laboratory laser experiments. The nonrelativistic calculations will also be examined in the context of recent experiments using photon-induced near-field electron microscopy in detail.

Oct. 10: David Hatch, IFS UT Austin

Title: *New Strategies for Dramatically Increasing Confinement*

Abstract: TBA

Oct. 10: Brad Shadwick, University of Nebraska, Lincoln, NE

Title: *TBA*

Abstract: TBA

Oct. 24: Masaru Furukawa, Tottori University, Japan

Title: *Stability analysis of MHD equilibria via simulated annealing*

Abstract: Simulated annealing (SA) is a kind of relaxation method, where we solve an initial-value problem derived for a Hamiltonian system so that the energy of the system changes monotonically while the Casimir invariants are preserved. We have applied SA for reduced MHD systems, where the energy is decreased by SA. Recently, it was shown that SA can be used for stability analyses since it tries to find a lower energy state. We found that spectral analysis of linearized SA equation shows instability for a cylindrically symmetric equilibrium with sheared poloidal rotation, where spectral analysis of linearized low-beta reduced MHD itself does not show instability. This indicates that a perturbed state has a lower energy, and that a negative energy mode exists. In the talk, the linear spectral analysis as well as the SA results including recent progress will be presented. Another analysis of a system with magneto-rotational instability (MRI) will also be included.

Oct. 26: Jacobo Varela, University Carlos III of Madrid, Spain
Title: *Synergies between nuclear fusion, astrophysical and industrial plasmas: prospective challenges*
Abstract:

The aim of this presentation is sharing a list of new research topics that connect different Plasma Physics fields. Nuclear fusion plasma studies will be dedicated to identifying the AE/EPM activity in several Stellarator and Tokamak devices, identifying optimization trends to improve the heating efficiency of external actuators as the NBI, ECH and ICRH, including both the linear and saturation phase of the AE/EPM. Astrophysical analysis will be dedicated to study the interaction of the stellar wind with exoplanets (with and without intrinsic magnetic fields) orbiting different stellar spectral types at different evolution times, including Sun-like stars, M and F stars as well as neutron stars. In addition, radio emission from exoplanets will be modeled and compared with radio telescopes observations. The model to study liquid metal flows dedicated to cooldown DCLL blanket in nuclear fusion reactors will be extended to improve the description of the heat transfer, identifying the optimized operation that maximize the heat removal and reduced the vorticity level and pipe erosion.

Nov. 28: Christopher Eldred, Sandia National Laboratory
Title: *TBA*
Abstract: TBA