Course Topics

Updated 29 January 2018

A) Basics of MHD

   i) MHD equations, content
   ii) Freezing-in Law, Alfven’s Theorem
   iii) Energy and momentum relations, magnetic tension
   iv) Virial Theorem, Stellar Collapse

B) MHD Dynamics I

   i) MHD Waves, Fredericks Diagram
   ii) Reduced MHD, Model Structure, Drift Wave Models
   iii) Nonlinear Alfven waves, basics of collisionless shocks

C) Non-ideal MHD I

   i) Local: Sweet–Parker Model
   ii) Magnetic Helicity
   iii) Global: Prandtl–Batchelor Theorem, Flux Expulsion

D) Wave Interactions

   i) 3-wave interactions, Manly–Rowe relations
   ii) Wave kinetics, non-local interactions, wave cascades
   iii) Decay instability of Alfven wave

E) Basics of MHD Turbulence

   i) Navier–Stokes Turbulence — a very brief review
   ii) MHD turbulence — basic ideas, Alfven effect
   iii) Kraichnan-Iroshnikov and Goldreich-Sridhar Scalings, critical balance

F) Stability I — Ideal

   i) MHD Energy Principle — formulation
   ii) Examples
      a) Rayleigh–Bernard
      b) Rayleigh–Taylor (review)
      c) Interchange, line-tying
   iii) Magnetic instabilities
a) Sausage mode and hydro-analogue
b) Kink, Kruskal–Shafranov Criterion
c) MRI

G) Stability II — Resistive
   i) Basic ideas of resonances, resistive modes
   ii) Fast, slow resistive interchange
   iii) Tearing, magnetic island formation

H) Non-ideal MHD II
   i) Stochastic magnetic fields, transport
   ii) Magnetic helicity, selective decay, Taylor Relaxation II
   iii) Basics of dynamo theory
   iv) Mean field electrodynamics — an introduction

I) MHD Shocks
   i) Gas–dynamic shocks, entropy production, Rankine–Hugoniot conditions
   ii) MHD shocks: parallel, perpendicular, oblique; deHoffmann–Teller Frame
   iii) More on collisionless shocks