Course Topics

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

E) 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

F) Wave Interactions

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

G) Basics of MHD Turbulence

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

H) Stability II — Resistive

i) Basic ideas of resonances, resistive modes
ii) Fast, slow resistive interchange
iii) Tearing, magnetic island formation

I) 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

J) 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