

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