Hydrodynamic Stability and Dynamo Theory

9 – 20th December 2016

Overview

The topics of the course, related to recent astrophysical and geophysical problems, are also very attractive to applied mathematicians. Sophisticated mathematical approaches applying wide spectra of numerical as well as analytic and asymptotic methods are necessary for successful and effective solutions of those physical problems. The first goal of the course is to motivate mathematicians to solve complex physical problems. Therefore, the course indicates an attractiveness and practical usefulness of topics related to the magnetic fields generation of cosmic bodies, in particular of the Earth and Sun. Understanding and the ability to predict the time behaviour of the last two fields has also enormous practical significance, and it is not yet solved. The second goal is to show how various branches of mathematics are indispensable in solving the problems of Convection and Dynamo Theory in astro- and geophysics. The 3rd goal is to introduce the basic physical background for the topics with emphasis on mathematical expression of this physics, i.e. to underline the correspondence between the physics and mathematics of the topics.

The foundations of Magnetohydrodynamics combined with Rotating Convection issues pertaining to two (also historically) important branches of Dynamo Theory, i.e. (1) Hydrodynamic Stability of rotating fluids permeated by magnetic field (Rotating Magnetoconvection) and (2) Kinematic Dynamos, which finally make the full Dynamo Theory tractable. All this story is presented by mathematical approaches with convenient approximations based on physical understanding of details in Dynamo mechanisms.

The course will benefit the students of undergraduate and postgraduate levels, and academicians with background of mathematics and physics to acquire a new experience to apply mathematical methods in attractive physical problems.

Modules	Foundations of Magnetohydrodynamics (MHD). Dynamics of Rotating Fluids: Rotating Magnetoconvection (RMC), Linear and nonlinear Models of RMC, Waves In Rotating MHD Systems, Numerical modeling in RMC Dynamo Theory: Numerical Simulations of Dynamos, Natural Dynamos. ***Course Duration: 10 days (9 – 20th December 2016, excluding Sundays 11th and 18th Dec. 2016)*** ***Number of participants for the course will be limited to fifty (50).***
You Should Attend If…	▪ you are a mathematician/ physicist/ geophysicist/astrophysicist/ engineer/research scientist. ▪ you are a undergraduate/postgraduate student / researcher / faculty or scientist from technical and academic institutions / from industry interested in learning to do research on MHD, RMC and dynamo theory. ▪ you keen to learn how to apply mathematical methods in astro- and geophysical models.
Fees	**Faculty** (Internal and external) and **Scientists**: Rs.4000/-. **Participants from Research Organizations / Industry / Consultancy firms**: Rs.8000/-. **Students and Research Scholars:** Without award of grade : Rs.1000/- ; With award of grade:Rs.2000/-. **Participants from abroad:** Students: USD $100; Other participants from abroad: USD $200. The above fee includes all instructional materials, computer use for tutorials and assignments, laboratory, free internet facility, working lunch with mid-sessions tea & snacks. The participants from industry/research organizations/academic institutions will be provided with twin sharing accommodation on payment basis in the Institute Visitors Block subject to the availability. Students will be provided accommodation in Student Hostels on payment basis. Travelling allowance will not be provided. All course registrations will processed via the national GIAN portal (gian.iitkgp.ac.in), where a Rs.500/- one-time fee is payable in addition to the above amount. Please send an email to course coordinator in case of any questions: hprani@nitw.ac.in

Course Schedule

Day/Topic	Time	L/T	Topic
Day 1 Foundations of Magneto-hydrodynamics (MHD)	9:30-11am	L1	Introduction and basic equations of MHD
	11.15-12.30pm	L2	Nondimensional numbers, e.g. magnetic Reynolds number(Rm); induction equation analysis, case Rm << 1with negligible induction effect
	14:00 -15pm	L3	Frozen flux approximation, case Rm >> 1
	15.15 -17pm	T-1	Assignments of Day1 lecture
Day 2 Dynamics of Rotating Fluids	9.30-11am	L4	Significant effects of Coriolis force in astro-physical bodies and in the Earth's outer core
	11.15-12.30pm	L5	Boundary layers effects
	14:00-15pm	L6	Geostrophic and quasigeostrophic approximation
	15.15 -17pm	T-2	Quiz on Day 1 lecture(10 marks); Assignments of Day2 lecture
Day 3 Rotating Magneto-convection (RMC)	9.30-11 am	L7	Introduction to Rotating Magnetoconvection
	11.15-12.30pm	L8	Basic equations for the RMC and nondimensional numbers;
	14.00-15pm	L9	Magnetostrophic and quasigeostrophic approximation
	15.15-17 pm	T-3	Quiz on Day 2 lecture(10 marks); Assignments of Day3 lecture
Day 4 Linear Models of the RMC	9.30-11am	L10	Geometry simplifications: the RMC in planar layer, the Cartesian box,
	11.15-12.30pm	L11	Busse cylindrical annulus;
	14:00 -15pm	L12	various complexities, e.g. anisotropic diffusive coefficients
	15.15-17 pm	T-4	Quiz on Day 3 lecture(10 marks); Assignments of Day4 lecture
Day 5 Nonlinear Models of the RMC	9:30-12:30pm	L13, L14	Weakly nonlinear analysis in various approximations;
	14.00-15pm	L15	The Nusselt number computation
	15.15-17pm	T-5	Quiz on Day 4 lecture(10 marks) Discussion on Assignments given on Day1-4 lectures (20 marks)
Day 6 Waves In Rotating MHD Systems	9:30-11am	L16	Dynamics of various waves
	11.15-12.30pm	L17	Dispersion equations of inertial, Alfvén, Lehnert (MC), MAC waves (their mostly asymptotic analysis)
	14.00-15pm	L18	Rossby waves modified by magnetic fields and/or by buoyancy
	15.15-18pm	T-6	*Micro Presentation (5mts duration each) on Day 1-5 lectures (10marks) Quiz on Day 5 lecture(10 marks); Assignments of Day6 lecture
Day 7 Numerical modelling in RMC	9:30-11am	L19	Introduction to Numerical methods and approaches (NMA)
	11.15-12.30pm	L20	NMA due to the (complex) spherical shell geometry
	14.00-15pm	L21	NMA due to more complex basic fields and quantities
	15.15-17pm	T-7	*Micro Presentation (5mts duration each) on Day 1-5 lectures (10marks); Quiz on Day 6 lecture(10 marks); Assignments of Day 7 lecture
Day 8 Dynamo Theory	9:30-11am	L22	Kinematic dynamos, toroidal and poloidal fields
	11.15-12.30pm	L23	Mean field dynamo theory, alpha and omega effects
	14.00-15pm	L24	Convection driven dynamos
	15.15-17pm	T-8	Quiz on Day 7 lecture(10 marks); Assignments of Day8 lecture
Day 9 Numerical Simulations Of Dynamos	9:30-11am	L25	Numerical methods, pseudo-spectral methods
	11.15-12.30pm	L26	LES models, the DNS approaches
	14.00-15pm	L27	Planetary dynamos scaling laws
	15.15-17pm	T-9	Quiz on Day 8 lecture(10 marks); Assignments of Day9 lecture
Day 10 Natural Dynamos	9:30-11am	L28	Internal structure and magnetic fields of cosmic objects (planets, stars,galaxies)
	11.15-12.30pm	L29	Natural Dynamos (the Geodynamo; planetary, Solar, stellar and galactic dynamos)
	14.00-15pm	L30	Conclusion on Natural Dynamos
	15.15-18pm	T10	Quiz on Day 9 lecture(10 marks); Minisymposium (20marks)

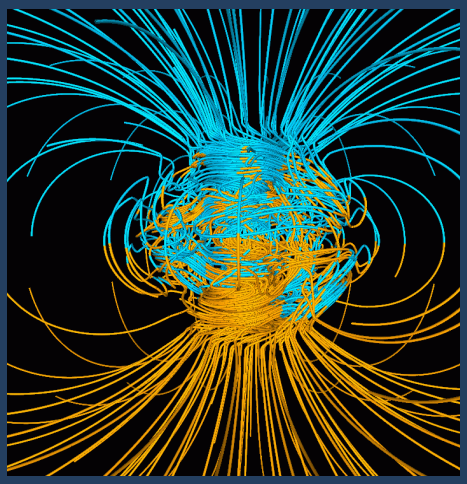
*Depends on the number of participants. L/T- Lecture/Tutorial

Evaluation and weightage of scores: Quiz starting from Day 2 – day 10= 90marks;
Micro Presentation (5mts duration each) on Day 1-5 lectures (5marks); Minisymposium (5marks)

The Faculty

Prof. Brestensky is from Faculty of Maths, Physics and Informatics (FMPHI) in Comenius University (CU), Bratislava, Slovakia. He contributed his research knowledge in different departments of CU such as Astronomy, Physics of the Earth and Meteorology, General Physics, Geomagnetism and Magneto-hydrodynamics, and Natural Sciences. His research interests include Geophysics, Geophysical Flu id Dynamics, Planetary Magnetic Fields, Rotating Magnetoconvection, Cosmic Magnetohydrodynamics, Solar Physics, Physics of everyday life and Applied Mathematics. He contributed his vast knowledge in the prestigious Scientific committees in different positions. He has been invited by the different prestigious universities, to name a few, Cambridge University, University of Hyderabad and NIT Warangal. He published his research work in high impact factor SCI journals which has a large number of citations.

Dr. HP Rani, Assistant Professor of Mathematics from NIT-Warangal has vast experience as an academician and a researcher by working in prestigious National Taiwan University, Taiwan and Kyung Hee University, South Korea. She has introduced a new concept of boundary layer flow visualisation through heatlines and masslines concept. Her work in flow assisted corrosion problems has gained currency in the nuclear industry. The detailed analysis of microcirculatory blood flow in hepatic lobule has got much appreciation from the medical community. She published 37 research articles in reputed International Journals, 19 research articles in the international proceedings and visited many countries for her research presentation as well as an Invited Speaker. Her area of interest includes Computational Fluid Dynamics, Heat and Mass Transfer, Biomechanics, MHD, geodynamo and corrosion problems.



Course Co-ordinator

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