Selected topics in Geophysical and Astrophysical Fluid Dynamics

The dynamics of planets, stars and galaxies is deeply linked to nonlinear physics. The considerable progress of this discipline in the last decades has dramatically changed our understanding of many natural phenomena. This is partly due to the ubiquity of fluid flows in the atmospheres and interiors of planets and stars. It is now clear that geophysical and astrophysical fluid dynamics (GAFD) differs from traditional fluid mechanics in that it deals with turbulent, sometimes electrically conducting, and most often rapidly rotating and highly stratified flows. These properties lead to a multitude of nonlinear behaviors, and constitute the core of this course.
We list the different topics that will be presented

Chapter 1 : Rotating flows. *Coriolis force – geostrophic balance – Proudman-Taylor theorem.*
Chapter 2 : Electrically conducting fluids. *Magnetohydrodynamics – dynamo instability -alpha and omega effects – chaotic field reversals*
Chapter 3 : Thermal convection. *Rayleigh-Benard instability – pattern formation -Secondary instabilities.*
Chapter 4 : Stably-stratified flows. *Internal gravity waves, double-diffusion, baroclinicity*
Chapter 5 : Astrophysical turbulence. *Angular momentum transport – accretion disks – rotation of radiative stars – Tayler-Spruit dynamo.*

Prerequisites of the unit :

Basic hydrodynamics (Eulerian or Lagrangian description, Navier-Stokes equation)

No prerequisite is expected for what concerns electromagnetism.

Bibliography :

H.K. Moffatt, Magnetic Field Generation in Electrically Conducting Fluids, Cambridge University Press

S. Chandraskhar, Hydrodynamic and Hydromagnetic Stability 1961, Clarendon Press, Oxford; reprinted by Dover Publications, Inc., 1981.

Credits: 3 ECTS

Hours: 32 hours.