*Summer School on **Non-Homogeneous Fluids and Flows***

Outline of course lectures (as of May 5, 2012)

Vincenzo Armenio

Turbulence in Stratified Flows

- Generality and governing equations of stratified flows
- Homogeneous turbulence in stable stratified flows
- Wall bounded turbulence in stable stratified flows
- Numerical modeling of stratified flows

Vladimir Zeitlin

***Multi-layer Rotating Shallow Water** - a mathematical laboratory for studying large-scale geophysical and astrophysical flows*

- Fundamentals: basic properties of the model, waves vs. vortices, geostrophic adjustment.
- Geostrophic vs ageostrophic instabilities and their saturation: barotropic, baroclinic and inertial instabilities; instabilities of coastal currents and density fronts.
- Wave-wave and wave-meanflow interactions: parametric excitation of waveguide modes and structure formation.
- Beyond the standard model. More physics: moist-convective rotating shallow water and shallow-water magnetohydrodynamics.

Chantal Staquet

Internal Gravity Waves

- Internal gravity waves : basic properties, resonant interactions, wave-induced mean flow.
- Interactions of internal gravity waves with a mean flow : background.
- Interactions of internal gravity waves with a mean flow : application to the atmosphere.
- Wave induced mean flow in the Southern Ocean.

Philippe Fraunié

Turbulent Mixing in Atmosphere and Ocean

- Vertical mixing in stratified flows, Lagrangian methods, double diffusion, turbulent measurements, HF and VHF radars.

High Resolution Numerical Methods for Atmosphere and Ocean

- Shallow water models, conservative schemes, spectral elements and applications, two phase flows.

Eleuterio F. Toro

Advanced Numerical Methods for Hyperbolic Equations and Applications

- Introduction to numerical methods for hyperbolic equations.
- Numerical fluxes for finite volume and DG methods.
- High-order non-linear methods: the ADER approach.
- A case study: blood flow in vessels with variable material properties.

Dmitri Kuzmin

Finite Element Methods for Convection-Dominated Transport Equations with Applications to Incompressible Flow Problems

- Stabilization techniques for convection-diffusion equations: upwinding, artificial diffusion, Petrov-Galerkin and Taylor-Galerkin methods.
- Methods for problems with steep fronts: discontinuity capturing terms, discrete maximum principles, flux-corrected transport algorithms.
- Finite element solvers for nonlinear systems: incompressible Navier-Stokes equations, k-epsilon turbulence model, moving boundary problems.

Eduard Feireisl* & *Antonín Novotný

Mathematics of Complete Fluid Systems

- *Existence* of global in time solutions to the system for any finite energy initial data.
- Construction of *relative entropy* based on the thermodynamic potential called ballistic free energy and its implications on the stability of solutions.
- The principle of *weak-strong* uniqueness.
- Studying singular limits, in particular, the low Mach and high Reynolds number limits, stratified fluid flows.

Yuli D. Chaschechkin

Differential Models of Fluid Mechanics

- Foundations, complete solutions, new approach for experimental testing.

Adequate Fluid Mechanics Experiment

- Demands, available resources and some particular examples.