Numerical Simulations for Astrophysics -
An introduction to three state-of-the art codes

This series of lectures offers an introduction and a practical initiation to three codes that simulate physical phenomena relevant to astrophysics. The selected codes are state-of-the art examples of current developments in three very different fields : magnetohydrodynamics (solar loops, magnetic reconnection, accretion-ejection mechanisms, etc.), the evolution of structure in the Universe (growth of structure, effects of radiation, formation of galaxies, etc.), and the interactions between matter and radiation in photodissociation regions (structure of irradiated clouds, chemical species, dust grains, spectral energy distributions).

All courses take place at the Strasbourg Astronomical Observatory, 11 rue de l'Université, Strasbourg, in the amphitheatre of the main observatory building.

Computational MagnetoHydroDynamics : applications to Physics and Astrophysics (AMRVAC)

H. Baty [Observatoire Astronomique de Strasbourg] **9/3/2015 (9:00-17:30)**

The focus of this lecture is on the use of modern numerical codes for the simulations of physical problems for which the magnetohydrodynamic approach applies (MHD). The MHD model couples Maxwell's electromagnetic equations and hydrodynamic equations. It is fully justified for collisional plasmas, and a first order approximation for semi-collisional plasmas. The numerical approach adopted in the AMRVAC code will be described, and the usage of this code will be illustrated with live demonstrations for three well chosen problems already published in the literature.

The physics and chemistry of interstellar clouds (PDR, DustEM)

Laurent Verstraete [Institut d'Astrophysique Spatiale, Orsay]
Franck Le Petit [Observatoire de Paris] **12/3/2015 (9:00-17:30)**

The aim of this lecture is for attendants to get to know the codes PDR (pdr.obspm.fr) and DustEM (www.ias.u-psud.fr/DUSTEM). Codes such as PDR (PhotoDissociation Regions) implement detailed models of the microscopic processes that occur in molecular interstellar gas : chemistry, matter-radiation interactions, heating and cooling processes. They provide predictions for the structure of interstellar clouds and the intensities of numerous emitted spectral lines. DustEM on the other hand focuses on processes related to dust grains, that coexist with the gas. The usage of such suites of codes has become inevitable for the interpretation of observed spectra of molecular regions in the Milky Way and other galaxies. The course will combine lectures and a practical approach.

The evolution of structure in the Universe (RAMSES)

Pierre Ocvirk [Observatoire Astronomique de Strasbourg] **19/3/2015 (9:00-17:30)**

RAMSES (Teyssier et al. 2002) is a numerical simulation tool for the study of the evolution of large scale structure and of the formation of galaxies. It uses a particle-mesh formalism to describe gravitation, and gas processes are implemented using adaptive refined mesh methods, which make it possible to combine high spatial resolution and an efficient exploitation of numerical ressources (memory & CPU). This code is widely used because of its modular structure and its optimisation for large computing architectures (>100 000 cores). The course will be given as a series of practical exercises.