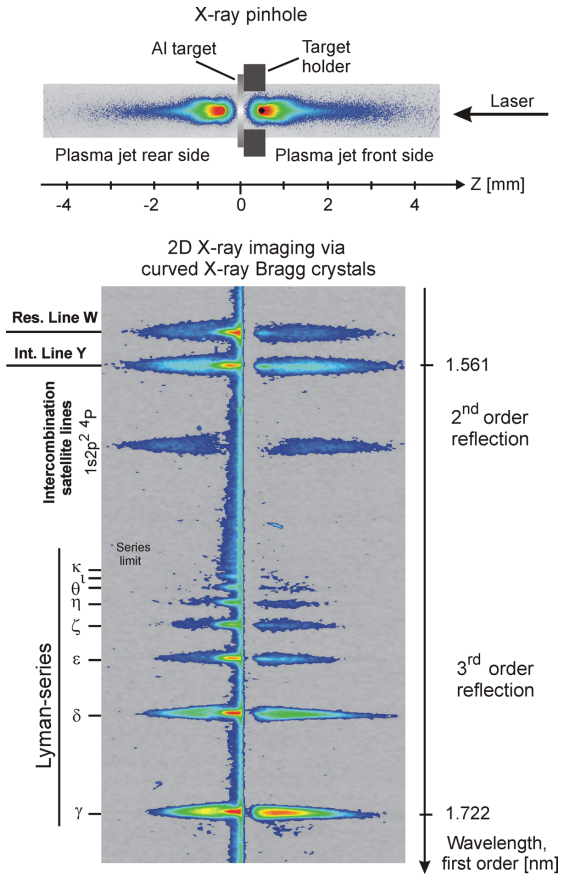
Title : **Atomic, molecular and radiation physics**
Acronym : TC7
EU Coordinator : Frank ROSMEJ, Laboratoire de l'Utilisation des Lasers Intenses (LULI)
Teaching staff :F rank ROSMEJ, Christophe LAUX
Pre-requisites : First year of MSc in Physics or Engineering Schools.
Credits : 3 ECTS
Language : French/English
Keywords : atomic and molecular structure, collisional-radiative processes, radiation, fusion, lasers, discharges.

This module has two parts. The first one recalls the quantum bases of atomic and molecular physics, and then presents the concepts of atomic and molecular ionization state distributions. The second part establishes the links with statistical physics to present the foundations of the dynamic physics of plasmas, then introduces the elements necessary for the modeling of chemical kinetics in plasmas, and finally presents the concepts of radiation and atomic and molecular spectroscopy. The course includes tutorials on the application of these concepts to different types of plasmas (hot fusion plasmas, cold process plasmas, natural plasmas).



A kilojoule ns laser irradiates a solid Al foil and generates highly ionized plasma jets. The jets penetrate into the ambient gas and the interaction is visualized via 2D X-ray imaging. Inside the plasma jets characteristic intensity variations are observed.

The topics covered are the following:

Introduction. Two-level atom, amplitude model, density matrix, diagonal and non-diagonal populations, Einstein coefficients.

Atomic and molecular structure. Hydrogen like atom, multiple electron atom, mean potential and Hartree-Fock method, concept of the optical electron, H_2^+ molecule, Born Oppenheimer approxi-mation, H_2, hybrid, electronic configurations, rotation, vibration (diatomic), orders of magnitude in molecular physics.

Population of atomic and molecular states. Particle statistics, partition functions, populations of atomic and molecular states, equations of state, Boltzmann and Maxwell distributions, complete and local thermodynamic equilibrium.

Thermodynamic properties. Heat capacity, enthalpy, entropy, free energy, pressure, viscosity,… for atoms and diatomic systems.

Elementary collisional processes. Principle of microreversibility, detailed balance, Hamiltonian, CPT invariance, cross section, reaction rate, mean free path, elastic collisions, excitation / deexcitation, ionization / recombination, electronic attachment and detachment, quenching, charge transfer, dissociation / recombination.

Radiation. Spectral lines (intensities, profiles), Planck's law and radiative temperature, radiation hydrodynamics, emission and absorption coefficients, continuous radiation, radiative transport equation, collisional-radiative models.

Applications. Magnetic fusion, inertial fusion, lasers (optical and XFEL), atomic physics, molecular physics, plasma discharges.