Title : **Tools for plasmas and fusion**
Acronym :TC1
EU Coordinator : Philippe SAVOINI, Laboratoire de Physique des Plasmas (LPP)
Teaching staff : Philippe SAVOINI
Pre-requisites : First year of MSc in Physics or Engineering Schools.
Credits : 3 ECTS
Language : French/English
Keywords : State of plasma. Characteristic space-time scales of plasmas (Debye length, plasma frequency, ...). Theories and models: orbit theory, kinetic theory, multi-fluid and Magnetohydrodynamics.

This module is an introduction dedicated to fulfill two objectives: (i) to introduce the basic concepts of the "plasma state" and (ii) to present the different theoretical approaches related to the multi-scale (time and space) aspect of thermonuclear, cold and/or space fusion plasmas. This course remains at a basic level as far as the applications are concerned and focuses on giving the most precise general view of the tools used in plasma physics.

Indeed, plasma - or the fourth state of matter - constitutes 99% of the visible matter in the Universe and is essentially formed of ionized gas. This "plasma state" is thus characterized by a set of charged particles influenced by long-range electric and magnetic fields, and by their feedback on these fields. . Plasmas are thus the result of two contradictory tendencies, a tendency to disorder due to thermal agitation and a tendency to organization due to the Coulombian interaction.

These two opposite behaviors between charged particles and electromagnetic fields makes the determination and calculation of the different space-time scales present within the plasma essential in order to understand both the dynamics of the plasma itself, but also and above all, the use of different theories and models used in plasma physics. Thus, among the different possible perimeters for this module, we have opted for a division according to these scales and their associated models in order to show the coherence and continuity of these different theoretical approaches. The course is divided into five parts:

Introduction :
- The space-time scales related to the electric and magnetic fields.
- Presentation of the different possible theories and models related to these scales.

Particle theory: a very useful approximation
- Electric and magnetic drift phenomena.
- Notion of adiabatic invariant : the mirror reflection.

Kinetic theory : a very complete statistical approach
- Statistical approach of plasmas :Klimontovitch equation.
- Vlasov and Boltzmann equations.

Multi-fluid theory: a global approach
- Determination of the fluid equations via the kinetic theory.
- Approximation and consequence on the dynamics of particles : Notion of closure laws.

MagnetoHydroDynamictheory : a "simplified" theory
- Determinations of the MHD equations from the multi-fluid theory.
- Limitations and areas of validity of MHD: use of Ohm's law.

This course is shared with the M2 "Master 2 Astronomy, Astrophysics and Space Engineering" (M2 A&A) in order to provide a common base on the "plasma state".

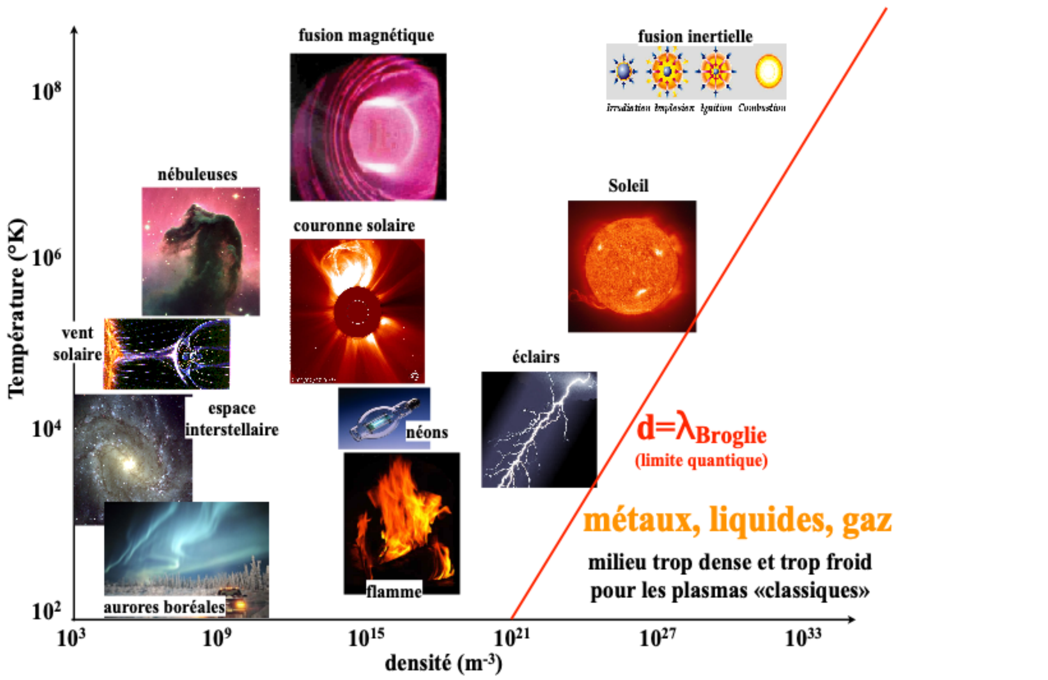

Diagram of temperature (T) and density (n), where are represented the principal observed plasmas. It can be noted that the range of values of T and n is counted in decades, making it essential to use theoretical models adapted to the plasmas studied.