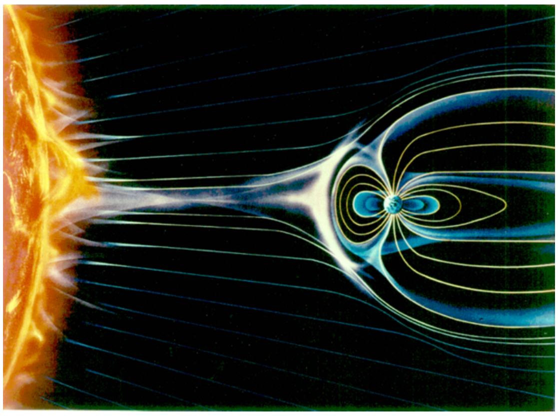
Title : **Space Plasmas**	
Acronym : O3	
EU Coordinator : Philippe SAVOINI, Laboratoire de Physique des Plasmas (LPP)	
Teaching staff :Philippe SAVOINI, Arnaud ZASLAVSKY	
Pre-requisites : First year of MSc in Physics or Engineering Schools.	
Credits : 3 ECTS	
Language : French/English	
Keywords : Space Plasmas & Astrophysics. Boundary zones and acceleration phenomena.	

The teaching unit presents the environment of magnetized stars. The concepts are presented mainly for the Earth and the planets of the Solar System - these environments, studied in-situ, are the best known. However, these concepts are applicable to more distant plasmas.



Artist's view of the interaction between the solar wind and the terrestrial magnetosphere. This image summarizes the different regions described in detail in the teaching unit, from the Sun to the Earth's ionosphere, passing through the collisionless shock wave present upstream of the magnetosphere.

The "space" plasma closest to us is located at an altitude of about 70 km, where the ionization of the upper atmosphere by solar UV radiation produces a resistive and magnetized layer of plasma, called the ionosphere.

Much further away, the interplanetary medium is traversed by a supersonic expanding plasma (300 to 800 km/second), coming from the Sun which is called the *Solar Wind*.

Between the two regions, there is a zone controlled by the Earth's magnetic field called the magnetosphere. The plasma in this region is collisionless, continuously out of thermodynamic equilibrium and subject to irregular reconfigurations of its magnetic topology.

From an astrophysical point of view, these regions represent a model that can be used to better understand other objects for which *in-situ* exploration is rare (magnetospheres of the planets Jupiter, Saturn, Uranus, Neptune) or even impossible (exoplanets, stellar corona, environments of magnetized stars such as young stars, pulsars, supersonic / super magnetosonic jets), etc.

From the point of view of plasma physics, the magnetosphere and the solar wind are excellent laboratories for the study of collisionless plasmas, very interesting for the understanding of transport processes in systems without resistivity or viscosity, turbulence, wave-plasma interactions, acceleration phenomena, etc.

The course is mainly devoted to basic concepts, illustrated with examples of applications in space physics and astrophysics. It is divided into 4 independent sections:

The solar wind: The Parker model of the solar wind is used; the notions of fast and slow winds, the transport of the solar magnetic field, and the variability of the wind are presented. These concepts are useful for the study of the environment of all "standard" stars, stars with matter ejection (T-tauri stars, red giants) and some compact stars (pulsars).

Notions of boundaries and discontinuities: The fluid approach allows us to classify the different boundaries that can exist in collisionless plasmas. These four boundaries (contact, tangential, rotational or shock) are present everywhere in our near environment (terrestrial shock, magnetosheath, magnetopause, neutral layer, lobes, plasmasphere, auroral zones) and are of universal interest in astrophysical plasmas.

The magnetosphere model: This region separating the ionosphere from the solar wind is one of the most complex regions of our immediate environment, where very important energetic phenomena such as magnetic substorms (source of the aurora borealis and australis) can occur. All magnetized planets have a magnetosphere. The environment of some stars is also treated as a magnetosphere: neutron stars, white dwarfs, black holes.

The ionosphere: This layer of plasma in contact with the neutral atmosphere of the Earth is the region where ionization and recombination processes take place. The concepts of Chapman ionization layer, plasma/neutral coupling, ionospheric current systems and ambipolar scattering are presented. These concepts are useful for the study of all planets with an atmosphere.