Course Description 2021

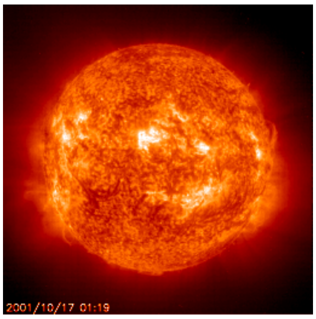
Space Physics (EF2240), 6 hp

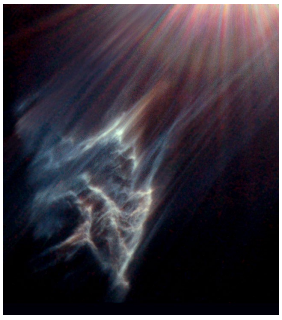
Course coordinator and teachers

Tomas Karlsson, tomas.karlsson@ee.kth.se, 08-790 77 01, Teknikringen 31, KTH.
(Course coordinator)
Savvas Raptis, savvra@.kth.se, +46 72 730 69 37, Teknikringen 31, KTH.

Introduction

More than 99% of matter in the universe is in the plasma state, i.e. in the form of an ionized gas. *Space physics* (also known as *space plasma physics)* is the subject which deals with these kinds of plasma populations and the phenomena associated with them. In space physics *in situ* measurements are often used (*"in situ"* is Latin for *"at location"*) with the help of satellites and space probes. This means that you can get information on quantities that are not easily observed at a distance, such as electric and magnetic fields, and plasma pressure and temperature. It therefore means that much of the research is concentrated to space physics phenomena in the vicinity of Earth and in the rest of the solar system, but also interstellar and intergalactic plasmas may also be considered to belong to the subject.



Three examples of space plasmas: the sun in ultraviolet light (why not visible light?), northern lights (why is it red at high altitudes and green at lower ones?), and an interstellar cloud (what are its dimensions?)

In this course we address space plasma physics phenomena associated with the Sun, the solar wind, the ionospheres (the upper ionized part of the atmosphere) and magnetospheres (the region in space dominated by the planets own magnetic field) of Earth and the other planets, space weather and briefly cosmic radiation, and interstellar and intergalactic plasma. The emphasis is on understanding, on being able to point to similarities between phenomena in very different plasma environments, on modelling of space physics phenomena with very simple mathematics, and on how measurements in space plasmas are carried out. In the course we will address some of the basics of plasma physics, which may be needed to carry out the above.

Learning outcomes

At the end of the course you should be able to

- define what a plasma is, and classify various types of plasma.
- describe the plasma physical properties of various regions of space, with emphasis of the near-earth region.
- explain how some important plasma populations in the solar system (e.g. Earth's ionosphere and magnetosphere) get their basic properties and how these properties can vary between the planets.
- make order of magnitude estimates of some properties of space plasmas and space physics phenomena, for example the power dissipated in the aurora or the magnitude of electric currents floating from the magnetosphere into the ionosphere.
- do simple analyses of measurement data from satellites and ground-based instruments. (E.g. calculate currents in space from magnetometer data.)
- make models of some space physics phenomena by applying basic physical laws expressed with simple mathematics. (An example would be to model the basic shape of the magnetosphere or estimate the temperature of a sunspot.)
- describe to interested laymen what we can learn from space physics and how it affects our everyday life (for example by various space weather phenomena.)

Litterature

C-G. Fälthammar, 'Space Physics' (compendium), 2nd Ed, Third Printing, 2001. (Abbreviated **CGF**.)

Larry Lyons, 'Space Plasma Physics', from *Encyclopaedia of Physical Science and Technology, 3rd edition, 2002.* (Abbreviated **LL**.)

Lecture notes and extra material.

The literature is free of cost and can be found in electronic form on the course home page.

COVID-19 adjustments

Due to the ongoing pandemic all the teaching this year will be done electronically, via Zoom meetings. Unless otherwise stated we will use the following Zoom meeting rooms for lectures and tutorials:

Lectures: https://kth-se.zoom.us/j/4080887604

Tutorials: https://kth-se.zoom.us/j/8106227164

This will also affect some other parts of the course, e.g. how the mini-groupworks are handled. COVID-19 adjustments are marked by red in this document.

Schedule

Activity	Date	Time	Who	Subject	Litterature
L1	30/8	13-15	TK	Course description, Introduction, The Sun 1, Plasma physics 1	**CGF** Ch 1, 5 (p 110-113)
L2	3/9	10-12	TK	The Sun 2, Plasma physics 2	**CGF** Ch 5 (p 114), 6.3
L3	6/9	13-15	TK	The Sun 3	**CGF** Ch 5 (p 115-121)
T1	8/9	10-12	SR	Tutorial 1, Mini-group work 1	
L4	10/9	10-12	TK	Solar wind, Plasma physics 3	**CGF** Ch 6.1, **LL** Ch I-III
L5	13/9	13-15	TK	The ionosphere 1, Plasma physics 4	**CGF** Ch 2, 3.1-3.2, 3.4-3.5
T2	15/9	10-12	SR	Tutorial 2, Mini-group work 2	
L6	17/9	13-15	TK	The ionosphere 2, Plasma physics 5	**CGF** Ch 3.7, 3.8
	17/9	24:00		Deadline hand-in, Mock exam example 1	
T3	20/9	13-15	SR	Tutorial 3, Mini-group work 3	
L7	22/9	10-12	TK	Earth's magnetosphere 1, Plasma physics 6	**CGF**, 4.1-4.3, 4.6, **LL** Ch IV.A
L8	24/9	10-12	TK	Earth's magnetosphere 2, Other magnetospheres	**CGF**, 4.8-4.9, **LL** Ch V
L9	27/9	13-15	TK	Aurora, Measurement methods in space plasmas and data analysis	**CGF** Ch 4.5, 10**, LL** Ch VI, Extra material
T4	29/9	10-12	SR	Tutorial 4, Mini-group work 4	
L10	4/10	13-15	TK	Space weather and geomagnetic storms	**CGF** Ch 4.4, 4.7, **LL** Ch IV.B-C, VII
	4/10	24:00		Deadline hand-in, Mock exam example 2	
L11	6/10	10-12	TK	Cosmic radiation, Interstellar and intergalactic plasma	**CGF** Ch 7-9
T5	8/10	13-15	SR	Tutorial 5, Mini-group work 5	
L12	11/10	13-15	SR, TK	Machine learning in space physics, Space plasma physics research at KTH	
	11/10	24:00		Deadline hand-in, Mock exam example 3	
T6	15/10	13-15	SR	Old exams	
Written exami-nation	25/10	8-13		M31-33	
	29/10	24:00		Deadline individual hand-in assignment	
TK = Tomas Karlsson, SR = Savvas Raptis					

About the teaching

The teaching is based on an active participation from you. To enable this lectures and tutorials will often contain short instances of reflection over some problem or discussions with the other course participants. During the tutorials "traditional" demonstrations of solutions to the exercises is alternated with mini-groupworks. These can give you bonus points to be added to the points obtained on the written exam (se below). The purpose of these activities is to stimulate deep learning geared towards an understanding and working knowledge, rather than a superficial learning of a large amount of facts.

Examination

During the course a certain amount of continuous examination takes place, in the form of five mini-group works (described below). For each mini-group work, a maximum of five points is given:

5 mini-group works (5×5 p = 25 p)

A new moment this year is one individual hand-in assignment to be performed and handed in at the end of the course. This will replace one of the problems in the written examination and will give a maximum of 20 p.

These points are added to the maximum 80 p that are given at the written exam. The following limits then determine the final grade:

Grade:	A:	100-125
	B:	90-99
	C:	81-89
	D:	66-80
	E:	50-65
	FX:	45-49
	F:	0-44

Mini-group work

At five of the tutorials the second hour will be used for a mini-group work (groups of about 3 persons put together randomly). An exercise will be presented, and the group shall solve this during at the latest 48 hours after the problem is presented. (Weekends are excluded from counting these hours, you will have two work days to hand it in.) A secretary is appointed; her/his task is to document the work. The goal is to produce a solution or a logically structured partial solution with a sketch of a method that will lead to a solution of the problem in question. The assignments are uploaded in Canvas and corrected. The solution is discussed briefly at the next tutorial or lecture.

Individual hand-in assignment

The individual hand-in assignment will be similar to the mini-group works, but will be personalized and should be solved individually. The time available fir solution will start one week before the examination week, and end at Friday during the examination week.

Written examination, 25/10, 2021, 08.00-13.00, M31-M33
For the written exam you may bring all the course material, any notes you have made, and a pocket calculator. (No computers are allowed, due to the possibility to communicate with the outside world.) The exam contains approx. 5 different problems (which may contain sub-problems). The character of the problems is such that to get a high score you will have to show that you have obtained a certain course goal, e.g. to make a reasonable order of magnitude estimate or figure out a simple model for some space physics phenomenon. At the tutorials we will spend some time working on problems similar to the examination problems.

Muddy cards (Last Minute)

The last few minutes of the lecture are spent on a short reflection of what you thought was important or unclear ("muddy") in today's lecture. (I call my version "Last minute". An example can be seen at the end of this document.) You can also add other comments if you like. This will take the form of an anonymous survey to be handed in in Canvas.

Mock Exam Examples

During the course you may try solving three examples of how exam problems can look like. You can (it is not obligatory) hand them in for correction. The problems will not give any points to add to your exam, it so solely for practice purposes. Solutions to the problems together with comments on the corrections will be presented at the following lecture. You will submit your solutions in Canvas as ungraded assignments.

Prerequisites

No formal prerequisites, but a reasonable background is some basic physics course (e.g. SI1135 Classical Physics).

Course home page

The Canvas Learning Management System will be will be used for the course home page: https://canvas.kth.se/courses/26751

At the home page I will post new information continuously. Here you can also find course material, the recorded lectures and tutorials, lecture notes, exercises, solutions, etc.

Course evaluation

The course evaluation will take place in Canvas after the written exam. A continuous evaluation takes place via the Last Minute surveys. You are of course welcome to give your opinion anytime about anything concerning the course, either to me personally, via e-mail or (if you want to remain anonymous) by posting a message in the KTH internal mail letter boxes. Address the message to 'Tomas Karlsson, Space and Plasma Physics, Teknikringen 31'.

Finally

If you have any questions during the course, don’t hesitate to contact me! I prefer to take questions after the lectures and tutorials, or via e-mail.

Last Minute!

What was the most important thing of today's lecture? Why?

What was the most unclear or difficult thing of today's lecture, and why?

Other comments: