



KTH Electrical Engineering

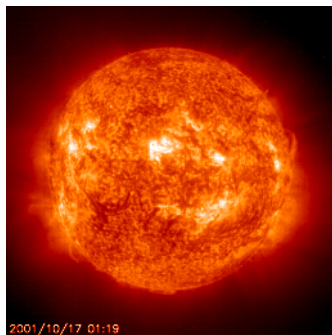
# Course Description 2016

## Space Physics (EF2240), 6 hp

### Course coordinator and lecturer

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### Introduction



*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?)*

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.

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.

## Course goals

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 or "the man in the street" 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 hand-out material.

The literature is free of cost.

## Schedule

<u>Activity</u>	<u>Date</u>	<u>Time</u>	<u>Room</u>	<u>Subject</u>	<u>Litterature</u>
L1	29/8	13-15	E52	Course description, Introduction, The Sun 1, Plasma physics 1	<b>CGF</b> Ch 1, 5, (p 110-113)
L2	1/9	15-17	L52	The Sun 2, Plasma physics 2	<b>CGF</b> Ch 5 (p 114-121), 6.3
L3	5/9	13-15	E51	Solar wind, The ionosphere and atmosphere 1, Plasma physics 3	<b>CGF</b> Ch 6.1, 2.1-2.6, 3.1-3.2, 3.5, <b>LL</b> Ch III, Extra material
T1	8/9	15-17	D41	Mini-group work 1	
L4	12/9	13-15	E35	The ionosphere 2, Plasma physics 4	<b>CGF</b> Ch 3.4, 3.7, 3.8
L5	14/9	10-12	V32	The Earth's magnetosphere 1, Plasma physics 5	<b>CGF</b> 4.1-4.3, <b>LL</b> Ch I, II, IV.A
T2	15/9	15-17	E51	Mini-group work 2	
L6	19/9	13-15	M33	The Earth's magnetosphere 2, Other magnetospheres	<b>CGF</b> Ch 4.6-4.9, <b>LL</b> Ch V.
T3	22/9	15-17	E51	Mini-group work 3	
L7	26/9	13-15	E31	Aurora, Measurement methods in space plasmas and data analysis 1	<b>CGF</b> Ch 4.5, 10, <b>LL</b> Ch VI, Extra material
L8	28/9	10-12	L52	Space weather and geomagnetic storms	<b>CGF</b> Ch 4.4, <b>LL</b> Ch IV.B-C, VII.A-C
T4	29/9	15-17	M31	Mini-group work 4	
L9	3/10	13-15	E52	Interstellar and intergalactic plasma, Cosmic radiation,	<b>CGF</b> Ch 7-9
T5	6/10	15-17	E31	Mini-group work 5	
L10	10/10	13-15	E52	Swedish and international space physics research.	
T6	13/10	15-17	E31	Round-up, old exams.	
Written examination	26/10	8-13	F2		

## 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 ( $5 \times 5 \text{ p} = 25 \text{ p}$ )

These points are added to the maximum 100 p that are given at the written exam. The following limits then determine the final grade:

<b>Grade:</b>	A:	111-125
	B:	96-110
	C:	81-95
	D:	66-80
	E:	50-65

### *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 treat this during approximately 45 minutes. 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 collected at the end of the tutorial and corrected. The solution is discussed briefly at the next tutorial or lecture.

### *Written examination, 26/10 2016, 08.00-13.00, F2*

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. You will write this down on the muddy card, which will be handed out. (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.

## **Prerequisites**

No formal prerequisites, but a reasonable background is some basic physics course (e.g. SK1112: Fysik I för M, T).

## **Course home page**

KTH Social will be used as a course home page:

<https://www.kth.se/social/course/EF2240/>

At the home page I will post new information continuously. Here you can also find lecture notes, exercises (and most of the solutions), etc.

## **Course evaluation**

The course evaluation will take place via internet after the written exam. A continuous evaluation takes place via the muddy cards. 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:**