Skolkovo Institute of Science and Technology, Skoltech
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Course "Data Analysis for Space Weather"

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Guest lecturers:
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OVERVIEW

The course introduces students to Solar-Terrestrial physics, Space Weather and practically useful approaches of data analysis for study, forecasting, and mitigation of space weather effects. The course provides an overview of Sun-Earth connections, starting from the interior of the Sun and ending in the Earth's magnetosphere. To gain insight into this field, we focus on such topics as: solar interior and solar structure, solar atmosphere, solar wind, solar flares and coronal mass ejections, as well as associated geomagnetic storms and polar auroras. These phenomena drive Space Weather with the implications for space-borne and ground-based technological systems (satellites, human spaceflight, airlines, power systems and pipelines). We also examine the space weather effects on technology and human health, hazard assessment, mitigation and forecasting, space environment data, scientific and service products.

Student Participation

To facilitate development of practical skills, foster active interest, and deep understanding, the course includes practical problems in the form of laboratory works and homework to be done with the usage of Matlab/Python, as well as a seminar and final project.

Course content and main topics

1. Introduction to Space Weather.
2. Sun as star and solar structure.
3. Solar atmosphere and solar wind.
4. Solar cycle and eruptive phenomena.
5. Eruptive phenomena and space weather.
6. Space weather in other planets

Laboratory works

1. Derivation of solar differential rotation from measuring sunspot positions.
2. Plank function.
3. Solar irradiance.
4. Luminosity in solar type stars.
5. Sunspots – magnetic field and temperature structure.
6. Flares – temporal evolution and magnetic field structure.
7. Dimmings and their relation to Coronal Mass Ejections.
8. Extreme Ultraviolet Waves and their characteristics.
9. Polar aurora forecasting.
10. Space weather in other planets.
11. Disturbance Storm Time Index Prediction

12. Case studies. Historical space weather events

Learning Outcomes

Knowledge

1. Knowledge of Sun-Earth connections and Space Weather effects on space-borne and ground-based technological systems.
2. Knowledge of Space Weather phenomena and main scientific and service products.
3. Knowledge of the state of art data analysis methods in Solar-Terrestrial physics and Space Weather, as well as their distinctive peculiarities and possibilities.

Skills

1. Skills in analyzing of the Space Weather phenomena, their sources and implications.
2. Skills in the detection of eruptive events on Sun and analysis of geomagnetic activity.
3. Skills in the developing data analysis algorithms for the detection, study and forecasting of space weather phenomena.

Experience

1. Experience in the analyzing Sun-Earth connections with implications for space-borne and ground-based technological systems.
2. Experience in working with space environment data, as well as service products for the production of space weather warnings.
3. Experience in predictive modeling and advanced data analysis methods for space weather and astrophysics.

Reading list:

1. Foukal, P.V., Solar Astrophysics, Wiley & Sons, 3. Aufl., 2013
2. Mullan, D., Physics of the Sun: a first Course, CRC Press, 2010
3. Antia, H.M., Bhatnagar, A., Ulmschneider, P. (Hrsg.), Lectures in Solar Physics, Springer, Berlin, Heidelberg, 2003
4. Bhatnagar, A., Livingston, W.: Fundamentals of Solar Astronomy, World Scientific, New Jersey, 2005
5. Russel, C.T., Luhmann, J.G., Strangeway, R.J., Space Physics: An Introduction, Cambridge University Press, 2016
6. Living Reviews on Solar Physics:
http://www.springer.com/astronomy/astrophysics+and+astroparticles/journal/41116;
Contains a number of review papers on various topics on solar physics. All articles are open access.