ASEN 6519 Aerospace Environments – Upper Atmospheres

Syllabus, Spring 2022

Lecture: AERO N250 T, Th 11:30-12:45 pm

Web page: Canvas course page

Instructor

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Course Overview

This multidisciplinary course is an advanced-level exposition of those neutral and plasma physical, dynamical, chemical, and electrodynamic processes that determine the observing states of the upper atmospheres and ionospheres of Earth and other planets. The overall context is the solar-terrestrial system, wherein energy from the Sun (i.e., visible, UV and EUV radiation; solar wind and interplanetary magnetic field) is transformed into various forms that facilitate flow into, and dissipation within, upper atmospheres. In part, specific topics to be covered will be determined by student needs and interests. The CU Space Weather Technology, Research and Education Center (SWxTREC) will also provide resources to assist students in computational labs that expose students to the latest modeling and data developments.

Class Learning Goals

The goals of this course are to expose students to the multidisciplinary field of upper atmosphere research and develop graduate students' research capabilities. Students will improve their analysis skills working with current upper atmosphere data sets, their research acuity by conceptualizing and understanding issues currently under study by the upper atmosphere community, their presentations skills by concisely and coherently presenting their analyses in a research conference format. Students will actively participate in the teaching-learning process through in-depth review of articles in the archival literature, and oral presentations of their analyses in class.

Prerequisites

Level of knowledge of the solar-terrestrial system similar to that of ASEN 5335 Aerospace Environments

Course Content

The class is broken into a number of sections, as follows:

- x Transport Equations for Upper Atmospheres (4 weeks)
  - o Boltzmann equation and velocity moments
  - o Transport equations: continuity, momentum, energy, pressure tensor and heat flow
  - o Maxwellian velocity distribution and closing the system of transport equations
  - o Euler and Navier- Stokes approximations
- x Upper Atmosphere: Thermosphere (4 weeks)
  - o Density and Composition Structure
    - ƒ Gas Diffusion and Vertical Structure
    - ƒ Eddy and Molecular diffusion
    - ƒ Minor versus Major gas diffusion
    - ƒ Plasma Diffusion
  - o Thermal structure

        - Energy sources and sinks
        - Exospheric temperature
        - Temperature profile
    - Collisions
        - Binary elastic collisions
        - Maxwell molecule collisions
        - Momentum transfer collision frequencies
    - Dynamics
        - Internal and External Forces
        - Wind systems
- Upper Atmosphere: Ionosphere (3 weeks)
    - Formation
        - Ionization
        - Chemistry
        - Layering
    - Thermal structure
        - Ion energy sources and sinks
        - Ion temperature profile
        - Electron energy sources and sinks
        - Electron temperature profile
- Upper Atmosphere: Electrodynamics (3 weeks)
    - Earth's magnetic field
    - Currents and Electric fields
    - Conductivities
    - Magnetosphere-Ionosphere Coupling
    - High Latitude Electrodynamics
    - Low Latitude Electrodynamics

- Student Final Report Presentations (1 week)

Texts

There are many books on upper atmospheres that you can access through the Engineering Library to provide a different point of view on the material we will cover in class. We will also be accessing journal articles from Journal of Geophysical Research, Geophysical Research Letters, Journal of Atmospheric and Solar-Terrestrial Physics and others. The primary books are:

- Ionospheres: Physics, Plasma Physics, and Chemistry, second edition, Robert Schunk and Andrew Nagy, Cambridge University Press, 2009
- Fundamentals of Plasma Physics, third edition, J. A. Bittencourt, Springer Science, 2004.

Supplementary material will come from other references:

- The Earth's Ionosphere, Plasma Physics and Electrodynamics, Michael Kelley, Academic Press.

- Physics of the Space Environment, Tamas Gombosi, Cambridge University Press.

Plagiarism

This course includes a research project and final written report. In constructing the research paper it is expected that ideas and concepts will come from specific reference material. It must be demonstrated that this material supports the original premise of your research project and is properly referenced.

Other Policies

Please be respectful of others during class time. This includes turning off your cell phone before class and not talking during class unless you have the floor.