PTYS/ATMO 544 – FALL 2024
Physics of the High Atmospheres

Instructor: Tommi Koskinen, Associate professor
Office: Kuiper Space Sciences room 421
Tel: 621-6939; Email: tommik@arizona.edu
Office Hours: after class (or any time when I am in the office)

Course Description: The study of the high atmosphere is critical to our understanding of the long-term evolution and chemistry of the atmospheres of the Earth and other planets. High atmosphere processes such as photochemistry, ionization, and atmospheric escape can shape the atmosphere as a whole and alter its evolution. A robust understanding of the physics and chemistry of high atmospheres is also important to remote sensing planetary atmospheres. The goal of this course is to develop a grasp of the key concepts and physical mechanisms underlying the thermal structure, composition, and dynamics of middle and upper atmospheres of the Earth and other planets, required for further research in this area.

Time and location: Tuesday and Thursday, 11.00-12.15pm, Kuiper Space Sciences room 312

Course prerequisites and co-requisites: There are no formal pre-requisites for this course. I will assume familiarity with classical physics, including: mechanics, electricity and magnetism, and mathematical methods of calculus (vectors, tensors, differential equations, and numerical methods).

Course format and teaching methods: Live in person, lecture, regular homework assignments, in-class assignments, individual term project

Course objectives: During this course, students will explore the key physical processes of dynamics, photochemistry, radiative transfer, and energy balance that control the composition and temperatures of the middle and upper atmospheres of the Earth, the planets in the solar system, and extrasolar planets. They will learn how to apply related concepts and processes to solve problems and characterize planetary high atmospheres. They will communicate the key elements of high atmosphere science and the results of their personal research project in writing and in presentations aimed at a scientific audience.

Expected learning outcomes: At the conclusion of this course, the students will demonstrate practical knowledge required to investigate high atmosphere phenomena in greater depth and start developing and running models of the middle and upper atmosphere.

Required texts and materials: There is no required textbook for this course. Reading assignments will consist of journal articles. In preparing for this course, I have used the following textbooks, in addition to my personal notes:

- R. W. Schunk and A. F. Nagy, *Ionospheres: Physics, plasma physics and chemistry*, Cambridge University Press. A handbook-style book, which reviews many topics.

- M. H. Rees, *Physics and chemistry of the upper atmosphere,* Cambridge University Press. A detailed exploration of the theory of the terrestrial thermosphere and ionosphere.
- T. Gombosi, *Gaskinetic theory,* Cambridge University Press. Kinetic theory from first principles, one of the best textbooks that I have read.
- M. L. Salby, *Fundamentals of atmospheric physics*, Academic Press. A standard text for atmospheric physics, including the middle atmosphere.
- J. W. Chamberlain, D. M. Hunten, *Theory of planetary atmospheres: An introduction to their physics and chemistry,* Academic Press. A classic textbook that focuses on the high atmosphere and comparative planetology.

Schedule of topics and activities (approximate):

Week 1: Terminology and scope
08/29: Preliminary quiz
Week 2: Kinetic theory and equations of motion
09/08: Term project topic due
Week 3: High atmosphere composition (Earth and planets)
Weeks 4 and 5: Ionospheres in the solar system
09/29: Term project plan due
Weeks 6, 7, and 8: High atmosphere energy balance (Earth and planets)
Week 9: Magnetospheres
Week 10: Magnetosphere-ionosphere coupling and the aurora
Week 11: Middle atmosphere chemistry and dynamics
Week 12: The middle atmospheres of the planets
Week 13: Thermal atmospheric escape, exoplanets
Week 14: Student presentations
Week 15: Student presentations
12/05: Term project due
Week 16: Conclusion

Assessments: Homework will be assigned roughly every other week. Homework assignments will be announced in class and supporting materials will be made available by the instructor. Homework assignments will focus on practical applications and/or derivations of key concepts related to in-class materials. Late homework will not be accepted without prior arrangement and a valid reason for extra time.

Each student is expected to complete a term project that focuses on a research question.

In-class participation will consist of class attendance and participation, presenting solutions to homework problems, and discussing journal articles. Journal articles will be assigned for reading throughout the course.

Your final grade will be based on your cumulative performance on homework, in-class participation, and the term project. The weighting of the assignments is as follows:

Homework assignments: 50%
In-class attendance and participation: 20%
Term project: 30%

Final Project: Each student must choose a topic for intense study during the semester. The instructor will provide a list of research questions that the students will choose from. The students may also propose their own research question for the instructor's consideration, as long as the topic clearly falls within the scope of the course. The students will hand in a term project report (due on 12/05) that answers the research question and deliver a related in-class presentation to their fellow students and the instructor. The expected length of the report is 7 publication units (where one publication unit is 500 words or one figure/table) and the time allocated to the presentations is 10 minutes + 5 minutes for Q&A.

Grading scale: The grade will reflect your final overall average according to the following scale: (A) 90-100%, (B) 80-90%, (C) 65-80%, (D) 50-65%.

Safety on campus and in the classroom: For a list of emergency procedures for all types of incidents, please visit the website of the Critical Incident Response Team (CIRT): https://cirt.arizona.edu/case-emergency/overview

Also watch the video available at https://arizona.sabacloud.com/Saba/Web_spf/NA7P1PRD161/common/learningeventdetail/crtfy000000000003560

Nondiscrimination and anti-harassment policy: The University of Arizona is committed to creating and maintaining an environment free of discrimination. In support of this commitment, the University prohibits discrimination, including harassment and retaliation, based on a protected classification, including race, color, religion, sex, national origin, age, disability, veteran status, sexual orientation, gender identity, or genetic information. For more information, including how to report a concern, please see: http://policy.arizona.edu/human-resources/nondiscrimination-and-anti-harassment-policy

University policies: All university policies related to a syllabus are available at: https://catalog.arizona.edu/syllabus-policies.

Graduate student resources: University of Arizona's Basic Needs Resources are available at: http://basicneeds.arizona.edu/index.html

Information contained in the course syllabus, other than the grade and absence policies, may be subject to change with reasonable advance notice, as deemed appropriate by the instructor of this course.