

Physics 650

Aeronomy and Auroral Physics 3 Credits

Instructor – Dr. Mark Conde



http://www.esa.int/var/esa/storage/images/esa_multimedia/images/2014/07/artist_s_view_of_atv-5_reentry/14605700-2-eng-GB/Artist_s_view_of_ATV-5_reentry.jpg

Overview

Description

This will be a graduate level introduction into the physics of Earth's upper atmosphere, and the auroral phenomena that occur within it. Topics to be covered will include:

- Basic properties of the upper atmosphere, and how it differs from layers below
- Radiative transfer in the upper atmosphere
- Survey of auroral phenomena
- Solar, interplanetary, and magnetospheric origins of the aurora
- Space weather influences
- Auroral forecasting
- Earth's ionosphere
- Earth's neutral upper atmosphere: kinetic theory, fluid dynamical description, Waves and tides
- Optics and spectroscopy of the airglow and aurora
- Tools and techniques for studying aeronomy and the aurora
- Recent research topics

The course will be rather broad; the goal is to provide a wide-ranging survey of aeronomy and the aurora subjects studied by the CEDAR and GEM communities, rather than developing detailed high-level theoretical description of individual focused topics.

After a couple of weeks introduction, will likely start each class with a brief discussion of current solar and interplanetary conditions, predicting space weather for coming days, and a debrief assessment of out previous predictions.

Course goals and student learning outcomes

Upon completion of this course students will:

- Understand the nature of Earth's upper atmosphere, ionosphere, and aurora
- Understand the societal relevance of these topics
- Be familiar with the tools and techniques used to study them
- Be aware of recent research directions in these fields

My goal as an instructor is to provide every student with maximum possible opportunity for success. This means that I try to be as flexible as possible with the course requirements, to avoid creating needless hurdles. Nevertheless, some penalties for missed or late work are necessary; my policies in this regard are outlined in subsequent sections.

Instructor information

Instructor: Dr. Mark Conde
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Office locations: Reichardt room 110 or 113.
Office Phone: 474-7741
Office hours: By arrangement

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Target schedule

<i>Week</i>	<i>Dates</i>	<i>Topics & Notes</i>	<i>Homework</i>
1	Jan 13 – Jan 17	Class introduction, Motivation, Basic atmospheric properties	
2	Jan 20 ¹ - Jan 24	Radiative transfer	H1 due
3	Jan 27 - Jan 31	Basic magnetospheric & auroral processes	
4	Feb 03 - Feb 07	Auroral morphology	H2 due
5	Feb 10 - Feb 14	Solar “weather”	
6	Feb 17 - Feb 21	Prediction and consequences of space weather	H3 due
7	Feb 24 - Feb 28	Kinetic theory	
8	Mar 03 - Mar 07	Earth’s ionosphere	Mid-term exam
9	Mar 10 - Mar 14	Spring Break	
10	Mar 17 - Mar 21	Thermospheric energy budget	
11	Mar 24 - Mar 28	Momentum, Navier-Stokes equations	H4 due
12	Mar 31 - Apr 04	Winds, atmospheric circulation	
13	Apr 07 - Apr 11	Waves and tides	H5 due
14	Apr 14 - Apr 18	Observing techniques & Instruments	Presentations
15	Apr 21 - Apr 25	Recent research topics	Presentations
16	Apr 28 - May 02	Finals week	Final exam
17	May 05 - May 09	Grades posted by May 7	

Course components and instructional methods

Instructional materials

Material for this course will be prepared electronically and will be available *over the web* via the “Canvas”² system at <https://north.open.uaf.edu/login/>. Material to be posted this way includes:

- Course syllabus (this document)
- Lecture notes (see comments below)
- Homework problem sets
- Supplementary handouts
- Online student grades

¹ Monday Jan 20 is Alaska Civil Rights Day. UAF does not hold classes, and most offices will be closed.

² All students should have access to Canvas. Please let me know if you have difficulties with this.

Lectures

I will be presenting lectures mostly using a computer, although I will supplement this with additional informal diagrams etc drawn on the blackboard. I intend to post printable versions of the electronic lecture notes online ahead of time.

Lectures are currently scheduled for 10:30 am - 11:30 am in Reichardt room 203. Once skies get dark enough, we will likely spend some time each lecture discussing auroral activity over the preceding night(s), and trying to predict what might happen over the next day or two.

Homework

Homework will be assigned every second week during the Monday lecture, and will be due at the Monday lecture two weeks later. Turn in your homework by handing it to me at the lecture. You may work with others on the homework problems, but you are prohibited from simply copying other's work. Homework will count significantly toward your final grade, as well as provide me with feedback regarding your understanding of the material.

Please realize that even if you submit a correct solution to a problem, I may not recognize it as correct if it's poorly presented. To maximize your chance of scoring well, your homework must:

- Be neatly laid out
- Be largely free from crossing out and over-writing
- Use grammatically correct English and be well enough written that the grader can understand what you're trying to say

Project

The reason I'm only assigning Homework every second week is to allow you time to work on a student project. In previous years, I have required projects to be submitted as essays, 10-15 pages in length, formally presented, and including detailed references. This did not work well – most essays were written at the last minute, and were of a standard well below that expected for a significant term project. So this year I propose instead to try something new, in which each student will present their term project as a 20-minute tutorial to the rest of the class on a topic that is of relevance to the course, but is not covered by my lectures (or is only mentioned briefly).

I have suggested a list of possible topics below. However, students may (after discussion with me) choose other topics of interest to them instead. My goal will be to have each student decide on their project topic within the first two weeks of class. This will help students have time to research their topic well, and it will also help me, because I will likely adjust the content of my lectures slightly depending on what topics will be presented in the projects. Here are some suggestions for possible project topics:

- Ionospheric signatures of earthquakes, tsunamis, and volcanoes
- Tropospheric and stratospheric forcing of the ionosphere and thermosphere by upward propagating waves and tides
- Ionospheric impacts resulting from total solar eclipses
- Auroral impacts on thermospheric chemistry: nitric oxide and O/N₂ ratio
- The EZIE cubesat mission

- The global atmospheric electric circuit – air-Earth current, lightning, sprites, elves, etc
- Equatorial aeronomy
- Meteor aeronomy, and formation of meteoric metal layers
- Applications of radio signal propagation through the ionosphere, and space weather impacts on operational systems
- Survey of ionosphere/thermosphere models in common use by the aeronomy community
- Applications of assimilative modeling and AI techniques for aeronomy and space weather applications
- RF techniques for ionospheric and atmospheric studies: ISR, SuperDARN, meteor radars, GNSS receivers, etc. (This could either be a broad but shallow survey of many techniques, or else a more in-depth discussion of one or two.)
- Aeronomic applications of space-based far-ultraviolet remote sensing instruments
- Applications of LIDAR for aeronomy
- Other measurement techniques – how do we measure upper atmospheric winds, temperatures, densities, and chemical composition?
- Black aurora and/or enhanced aurora
- Auroral electron acceleration mechanisms: “inverted-V” versus Alfvénic aurora
- STEVE
- Auroral conjugacy
- Polar-cap patches
- Pulsating aurora

One of the goals of the project will be to provide practice with how to present a classroom lesson on a scientific topic. This is a very different task to giving a science talk to a professional audience at a conference, or presenting a departmental colloquium³. Here the objective will be to explain your topic in a simple, logical, and clear way, so that other class members (and myself) learn something useful and actionable from your presentation.

Note that it is not possible to cover much ground in a short 20-minute lesson. But do not let this fool you into thinking that the project is a small task. Rather, it is quite the opposite: to do justice to a large topic in a short lesson, you will need firstly to become very familiar with the whole scope of your topic then, secondly, to ensure you understand the topic clearly enough to recognize the key ideas from within it and, finally, to distill these into a simple and clear story that captures the “take home” messages for your audience.

My grading for these projects will thus place at least as much weight on how clearly you explain your topic as it will on the material itself. Structuring the projects this way is new this year, so I do not have prior experience with how well the format will work in practice. I will discuss the projects with the class during the first week of the semester, including the possibility of incorporating class feedback on each presentation as a factor in assigning

³ 40 years of experience in scientific research has taught me that clarity (or even communication of actionable ideas) is rarely if ever the main objective of speakers at scientific conferences!

the grade. I will then post to our canvas class site a rubric for how I will grade them. This should help students prepare their presentations appropriately.

The general format for these 20-minute mini-lessons should be something like:

- Introduction of the topic or technique: For atmospheric processes, describe what region of the atmosphere are we discussing, and what phenomena or processes are being considered. Similar background information is also needed for a lesson on instruments or techniques, although the emphasis might be slightly different.
- Key ideas from this topic – a simple summary of the topic that would be enough for (say) a first-time undergraduate student attending a CEDAR or GEM conference to understand the main points of a conference talk on this subject.
- Why is this topic important in the context of current research, or for geospace operations?
- What are the important problems and/or next steps for researchers working in this area?

Exams

There will be one 60-minute mid-term exam during the semester and one take-home final exam. The preliminary dates for these are

- Mid-term: The week after spring break, exact date TBD
- Final: Take-home, completed during finals week.

No textbooks or printed material will be allowed in the mid-term exam, but you may bring in any amount of your own original (not photocopied) handwritten notes. You should also bring a calculator.

Course policies

Grading

The course grade will consist of the following components

- | | |
|------------------|-----|
| • Homework: | 25% |
| • Project | 30% |
| • Mid-term exam: | 20% |
| • Final exam: | 25% |

I will post all grades online, using the UAF's "Canvas" system⁴. All registered students have access to this system for checking their grades. Please do *check that I have posted all your grades correctly*, and let me know if you think there is an error. Also, please retain all work that we return after grading, in case an error does appear. Returned graded work is proof of your scores.

Final grades will be returned as letter grades with plus/minus modifiers. These will be derived from your overall percentage grade. The approximate conversions for each letter grade will be as follows. A: $\geq 90\%$; B: 75% to 90%; C: 60% to 75%; D: 50% to 60%; F: $< 50\%$. Plus/minus modifiers will subdivide each main grade into three equally spaced sub-levels.

⁴ <https://north.open.uaf.edu/login/>

Attendance

UAF policy⁵ states that “you are expected to adhere to the class attendance policies set by your instructors.” In general, I expect at least 90% attendance from all students. In this small class absences will not go unnoticed. In cases of low attendance, I will follow-up with relevant students to see if any accommodations could help. Students not turning in work and with very low attendance may be subject to an instructor-initiated withdrawal (depending on extenuating circumstances.)

Class participation

There is no requirement for you to participate actively in class by asking questions or joining discussions, and there is no grade component based on this. Nevertheless, you are of course free to ask questions at any time during the lectures. Because we have a large amount of material to cover, I may defer answering lengthy or numerous questions until after class.

Missed or late work

Problem sets will generally not be accepted after the due date, without evidence of illness or genuine emergency. Students having documented clashes with other UAF commitments may pre-arrange alternate homework submission deadlines with me. All decisions regarding late homework or alternate deadlines will be at the discretion of the instructor.

Student conduct and academic honesty

It is the responsibility of each student to be informed about the policies for student conduct and safety at the University of Alaska. You are encouraged to read these policies at <https://uaf.edu/csrr/student-conduct/> and links therein. It should go without saying that students are expected to do their own original work for all assignments. Copying from other students or indeed from any source that is not your own work constitutes plagiarism. Failure to comply with UAF policies may be considered academic misconduct and may result in a failing grade (either for individual portions of work, or for the entire course, depending on severity.) Serious cases will be referred to university authorities for possible further disciplinary action.

Student responsibilities

It is the responsibility of all students to be aware of the various requirements of the class. This includes knowing what work is required, when the deadlines are, and how this work should be turned in. These requirements are clearly outlined in the syllabus, and multiple reminders will be given in class. Lack of awareness of a requirement will not be regarded as an acceptable rationale for failing to meet it.

The department takes great care to ensure that all submitted work is graded fairly and that the resulting scores are correctly credited to the students who submitted the work. Nevertheless, scores occasionally do get entered incorrectly or missed altogether. **It is the responsibility of students to check their scores in Canvas frequently**, and to notify the instructor immediately any discrepancy is noted. As discussed earlier, students are also

⁵See <http://catalog.uaf.edu/academics-regulations/attendance/>

responsible for keeping all graded work returned to them, as evidence of the grade received, should any disparity arise later.

Course requirements and materials

Prerequisites

This course may be taken by UAF students enrolled for a graduate degree in natural sciences, or by undergraduate students by permission of the instructor.

Textbooks

Required: None

Recommended: Aeronomy, by Banks & Kockarts; Aurora, by Vallance-Jones

Both of these are out of print. But you can likely find them in the library or online.

Calculators

You will need access to a calculator to complete some of the homework problems. Calculators will also be permitted during exams. Remember that it is much more important to present the correct reasoning for solving a problem than it is to arrive at the correct numerical value. Please, explain your reasoning when presenting solutions to homework and exam problems. I will award partial points for correct reasoning, if presented, even if the final answer is incorrect or incomplete.

Support Services

Complaints and concerns

You are always welcome to discuss your concerns with me. However, if you have a concern that you feel cannot be resolved by discussion with me, you may wish to contact the Physics Department chair, Dr. Truffer. The University also has an Academic Advising Center on the 5th floor of the Gruening building, open Monday to Friday, 8 am to 5 pm and contactable via phone at 907-474-6396. While primarily focused on supporting undergraduates, the advising center can help with all student matters, from study tips to help with understanding the University's formal mechanisms for academic appeals. (See also <http://www.uaf.edu/advising/>)

Student Health and Counseling Center

The University provides health and counseling services through its Student Health and Counseling Center, which is located at 612 N. Chandalar Drive, on the 2nd floor of the Whitaker Building (the same building as Fire and Police, across from the bus turn around.) Their web site is at <http://www.uaf.edu/chc/>. The center will see students on an appointment basis. The number to call for an appointment is 474-7043. It is best to do so

at 8:00 AM in the morning, because they are scheduled daily on a first come first serve basis.

Disabilities and/or Special Needs

Every qualified student is welcome in my classroom. As needed, I am happy to work with you, disability services, veterans' services, rural student services, etc. to find reasonable accommodations. Disability services are provided free of charge, and are available to any student who qualifies as a person with a disability. Student seeking special accommodations for a disability must first discuss their needs with Disability Services. Call 474-5655 to schedule an appointment.

UAF Disability Services is located in the Whitaker Building, room 208. Extensive support is available, as described at <http://www.uaf.edu/disability/>

Effective communication: Students who have difficulties with oral presentations and/or writing are strongly encouraged to get help from the UAF Department of Communication's Speaking Center (907-474-5470, speak@uaf.edu) and the UAF English's Department's Writing Center (907-474-5314, Gruening 8th floor), and/or CTC's Learning Center (604 Barnette Street, 907-455- 2860).

Sexual Harassment and Discrimination

Students at this university are protected against sexual harassment and discrimination (Title IX), and minors have additional protections. Please be aware that if I notice or am informed of certain types of misconduct, then **I am required to report it** to the appropriate authorities. For more information on your rights as a student and the resources available to you to resolve problems, please go the following site: www.uaf.edu/handbook/.

UA is an AA/EEO employer and educational institution and prohibits illegal discrimination against any individual: <https://alaska.edu/nondiscrimination/>.

Emergency Notification Plan

Students will receive emergency notifications via phone or email. Please check your UAOnline account to confirm your emergency notification settings. For more information, please refer to the Student Handbook. In cases where you do not have access to your devices, as your instructor, I will take responsibility to relay any emergency notifications.

Extended Absence Policy

The university of Alaska Fairbanks recognizes that students may need to miss more classes than allowed by a particular instructor as specified in course policies. Extended absences are defined as missed classes or course work by students beyond what is permissible by the instructor's written course policies. Students may need to miss class and/or course work for a variety of reasons, including, but not limited to:

- Bereavement
- Personal illness or injury
- Serious illness of a friend, family member or loved one
- Military obligations

- Jury service

Other emergency or obligatory situations. For more information, go to the Students Hand book or the Center for Students Rights and Responsibilities.

Additional Support Services

- Speaking Center: 907-474-5470, speak@uaf.edu, Gruening 507.
- Writing Center: 907-474-5314, uaf-writing-center@alaska.edu, Gruening 8th floor.
- UAF Math Services: uafmathstatlab@gmail.com, Chapman 305 (for math fee paying students only)
- Developmental Math Lab: Gruening 406
- The Debbie Moses Learning Center at CTC: 907-455-2860, 604 Barnette St., Room 120.
- For more information and resources, please see the Academic Advising Resource List: https://www.uaf.edu/advising/lr/SKM_364e19011717281.pdf.

Syllabus Addendum

UAF requires all syllabi to include the following addendum. It specifies UAF's official position with regard to a number of important issues. Should there be any inconsistencies between this addendum and the course-specific syllabus presented above, the policies described in the addendum are the ones that will apply.

Syllabus Addendum (Revised 8/15/2024)

Student protections statement: UAF embraces and grows a culture of respect, diversity, inclusion, and caring. Students at this university are protected against sexual harassment and discrimination (Title IX). Faculty members are designated as responsible employees which means they are required to report sexual misconduct. Graduate teaching assistants do not share the same reporting obligations. For more information on your rights as a student and the resources available to you to resolve problems, please go to the following site: <https://catalog.uaf.edu/academics-regulations/students-rights-responsibilities/>.

Disability services statement: I will work with the Office of Disability Services to provide reasonable accommodation to students with disabilities.

ASUAF advocacy statement: The Associated Students of the University of Alaska Fairbanks, the student government of UAF, offers advocacy services to students who feel they are facing issues with staff, faculty, and/or other students specifically if these issues are hindering the ability of the student to succeed in their academics or go about their lives at the university. Students who wish to utilize these services can contact the Student Advocacy Director by visiting the ASUAF office or emailing asuaf.office@alaska.edu.

Student Academic Support:

- Communication Center (907-474-7007, uaf-commcenter@alaska.edu, Student Success Center, 6th Floor Room 677 Rasmussen Library)
- Writing Center (907-474-5314, uaf-writing-center@alaska.edu, Student Success Center, 6th Floor Room 677 Rasmussen Library)
- UAF Math Services (907-474-7332, uaf-traccloud@alaska.edu)

Drop-in tutoring, Student Success Center, 6th Floor Room 677 Rasmussen Library
1:1 tutoring (by appointment only), Chapman 210
Online tutoring (by appointment only) available

<https://www.uaf.edu/dms/mathlab/>, available at the Student Success Center

- Developmental Math Lab (Gruening 406, <https://www.uaf.edu/deved/math/>)
- The Debbie Moses Learning Center at CTC (907-455-2860, 604 Barnette St, Room 120, <https://www.ctc.uaf.edu/student-services/student-success-center/>)
- For more information and resources, please see the Academic Advising Resource List <https://www.uaf.edu/advising/students/index.php>

Student Resources:

- Disability Services (907-474-5655, uaf-disability-services@alaska.edu, 110 Eielson Building)
- Student Health & Counseling [**free counseling sessions available**] (907-474-7043, <https://www.uaf.edu/chc/appointments.php>, Whitaker Building 2nd floor)

- Office of Rights, Compliance and Accountability (907-474-7300, uaf-orca@alaska.edu, 3rd Floor, Constitution Hall)
- Associated Students of the University of Alaska Fairbanks (ASUAF) or ASUAF Student Government (907-474-7355, asuaf.office@alaska.edu, Wood Center 119)

Nondiscrimination statement: The University of Alaska is an affirmative action/equal opportunity employer, educational institution and provider. The University of Alaska does not discriminate on the basis of race, religion, color, national origin, citizenship, age, sex, physical or mental disability, status as a protected veteran, marital status, changes in marital status, pregnancy, childbirth or related medical conditions, parenthood, sexual orientation, gender identity, political affiliation or belief, genetic information, or other legally protected status. The University's commitment to nondiscrimination, including against sex discrimination, applies to students, employees, and applicants for admission and employment. Contact information, applicable laws, and complaint procedures are included on UA's statement of nondiscrimination available at www.alaska.edu/nondiscrimination.

For more information, contact:

UAF Office of Rights, Compliance and Accountability
1692 Tok Lane
3rd floor, Constitution Hall, Fairbanks, AK 99775
907-474-7300
uaf-orca@alaska.edu

Additional syllabus statement for courses that include off-campus programs and research activities:

University Sponsored Off-Campus Programs and Research Activities
We want you to know that:

1. UA is an AA/EEO employer and educational institution and prohibits illegal discrimination against any individual: www.alaska.edu/nondiscrimination.
2. Incidents can be reported to your university's Equity and Compliance office (listed below) or online reporting portal. University of Alaska takes immediate, effective, and appropriate action to respond to reported acts of discrimination and harassment.
3. There are supportive measures available to individuals that may have experienced discrimination.
4. University of Alaska's Board of Regents' Policy & University Regulations (UA BoR P&R) 01.02.020 Nondiscrimination and 01.04 Sex and Gender-Based Discrimination Under Title IX, go to: <http://alaska.edu/bor/policy-regulations/>.
5. UA BoR P&R apply at all university owned or operated sites, university sanctioned events, clinical sites and during all academic or research related travel that are university sponsored.

For further information on your rights and resources [visit the student placement guidelines page of the equity and compliance site](#).