ASTR–6000: SEMINAR IN ASTROPHYSICS

CU Boulder Syllabus (Spring 2022)

COLLAGE: Topics in Coronal Heating, Solar/Stellar Wind Acceleration, and Space Weather

Instructors:
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Course Times: Thursdays, 4:00–4:50 pm (Mountain), Duane Physics room E126

Course Web Pages: https://stevencranmer.bitbucket.io/ASTR_6000_2022/

Office Hours: TBD dates, times, & modes (in-person or virtual)

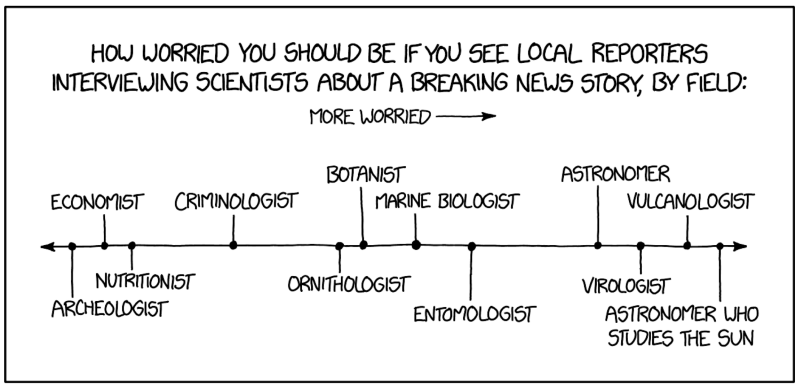
SUMMARY

This hybrid course is the ninth offering of the *George Ellery Hale Collaborative Graduate Education (COLLAGE)* program, a joint effort between CU Boulder, the National Solar Observatory (NSO), New Jersey Institute of Technology (NJIT), University of Hawai'i (UH), New Mexico State University (NMSU), Montana State University (MSU), University of Minnesota (UM), Georgia State University (GSU), and the High Altitude Observatory (HAO). We anticipate that graduate students from outside CU Boulder will take this course by registering for courses at their home institutions that are used for special topics, seminar-type discussions, or independent study. At CU Boulder, this course is a **one-credit seminar** graduate elective. The CU class will meet in person, but we will also hold synchronous Zoom sessions to join together everyone at all of the participating institutions (with additional instructors lined up to facilitate local discussions).

In this course, we will cover the physics of the solar corona, including a survey of proposed solutions to the "coronal heating problem," the extension of the Sun's magnetic field into the heliosphere, the acceleration and evolution of the solar wind and coronal mass ejections (CMEs), an introduction to the impacts of "space weather" on human life and society, and a summary of space weather forecasting.

COURSE GOALS

The overall goal of COLLAGE is to broaden the scope of graduate-level curricula beyond what is routinely available at any one institution, to include a series of focused-topic courses for students considering research in solar/space/heliospheric physics. By increasing exposure to cutting-edge science, we hope these courses will spark interest in doing research in these fields. We also want to help students build practical research skills, like coding (for which we will tend to use Jupyter notebooks in python), plotting one's results to optimize scientific communication, and how to get the most out of reading papers.



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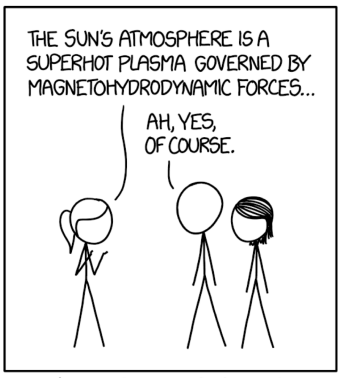

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WHENEVER I HEAR THE WORD "MAGNETOHYDRODYNAMIC" MY BRAIN JUST REPLACES IT WITH "MAGIC."

GRADING

This being a one-credit seminar, there are no midterm or final exams. The final course grade will be assembled from two main components:

Active participation in paper discussions (5 or 6)	50%
Computation assignments (2 or 3)	50%

Like many other seminars, we will organize a good fraction of our time around reading and discussing **scientific papers.** There will be about 5 or 6 paper-reading assignments, usually with a one-week turnaround and a due-date on the day of class that we will be discussing that particular topic. You'll be graded on the total number of "responses to prompts" that you submit online, and these come in two types:

1. Brief individual responses, seen only by the instructors, to top-level questions like "why did the authors do what they did?" and "why should we care?"
2. Public posts on a class-wide discussion board, in which you can ask questions about things you didn't understand or share details that you found particularly interesting. You're also encouraged to comment on, or respond to, other students' posts, but please be respectful and constructive.

It is still not yet clear how many papers we will read, but if there end up being N papers, you will earn full credit for these assignments by submitting at least $3N$ separate responses of either type. We will devote *a bit* of time in class to discussing and summarizing each online discussion, but we expect a good amount of closure (i.e., questions getting answered) to happen online, too.

We will also explore our topics in more depth by going through a few **hands-on computation exercises.** For those, the assignments for you will usually be to extend them in some way (i.e., add more physics or figure out new ways of visualizing the output) or, if python isn't your game, to re-implement them in some other language or code of your choice (maybe Mathematica or Julia?). There will also be at least one computation exercise that will be more open-ended—almost a mini-project—in which you will choose a topic and do something that goes beyond what we discussed in class. You could analyze some online data, reproduce some results from a paper, or follow up on any of the loose threads that we'll surely leave dangling. More information about these assignments will be made available soon.

COURSE MATERIAL

There are no required textbooks for this class. Relevant material will be distributed throughout the semester. For additional reading on several topics important to this course, see:

- Markus Aschwanden's book *Physics of the Solar Corona* (2nd ed., 2005) is a comprehensive source for all things coronal, and should be available as a free download to CU Boulder students who are logged into a colorado.edu domain. The same goes for May-Britt Kallenrode's 2004 book *Space Physics: An Introduction to Plasmas and Particles in the Heliosphere and Magnetospheres,* and the classic 1972 monograph by Art Hundhausen, *Coronal Expansion and Solar Wind.*
- Review papers can be an excellent source of up-to-date knowledge. See, for example, Cranmer and Winebarger (2019) for a survey of our understanding of coronal heating and solar wind acceleration, Viall and Borovsky (2020) for a review of the most important unanswered questions about the solar wind, and Pulkkinen (2007) and Temmer (2021) for a pair of reviews about space weather from the terrestrial and solar perspectives, respectively.
- Iver Cairns (U. Sydney) posted lecture notes from a 2010 course, with nice pedagogical surveys of the corona, solar activity, the solar wind, the heliosphere, and space weather.

Please see either instructor if you have difficulty obtaining any of the materials that you need.

SCHEDULE OF TOPICS

The following is a first draft of the dates on which we will discuss specific topics. The schedule on the web page will be kept up-to-date if there are changes.

1.	Jan. 13	Course overview: survey of data, jargon, & unanswered questions
2.	Jan. 20	Coronal heating: origins & scaling laws
3.	Jan. 27	Coronal heating: discussion & hands-on exercises
4.	Feb. 3	Coronal heating: physics of wave/turbulence concepts
5.	Feb. 10	Coronal heating: physics of reconnection/nanoflare concepts
6.	Feb. 17	Magnetic field extrapolation & the Parker (1958) solar wind
7.	Feb. 24	Solar wind: advanced physics; hands-on exercises
8.	Mar. 3	Solar wind: evolution, corotating streams, & the outer heliosphere
9.	Mar. 10	Coronal mass ejections (CMEs): acceleration, heating, & evolution
10.	Mar. 17	Space weather: the interplanetary space environment
11.	Mar. 31	Space weather: terrestrial responses & technological impacts
12.	Apr. 7	Space weather: case studies of historical events
13.	Apr. 14	Space weather: "research to operations" and forecasting
14.	Apr. 21	The solar/stellar connection: scalings & exoplanet impacts
15.	Apr. 28	Course summary & round-table discussion: what did we learn?

ACADEMIC INTEGRITY

All students enrolled in a University of Colorado Boulder course are responsible for knowing and adhering to the Honor Code academic integrity policy. Violations of the Honor Code may include, but are not limited to: plagiarism, cheating, fabrication, lying, bribery, threat, unauthorized access to academic materials, clicker fraud, submitting the same or similar work in more than one course without permission from all course instructors involved, and aiding academic dishonesty. All incidents of academic misconduct will be reported to the Honor Code (honor@colorado.edu; 303–492–5550). Students found responsible for violating the academic integrity policy will be subject to nonacademic sanctions from the Honor Code as well as academic sanctions from the faculty member. Additional information regarding the Honor Code academic integrity policy can be found at the Honor Code website.

For this course, I encourage you to discuss the assignments and topics with your fellow students. However, everything that is written up and submitted must be your own independent work. If you do collaborate with other students, a good time to split off from the group is when you start to write up your answers. If someone were to ask you questions about your work, you should be able to explain everything about how & why you did it the way you did.

ACCOMMODATION FOR DISABILITIES

If you qualify for accommodations because of a disability, please submit your accommodation letter from Disability Services to your faculty member in a timely manner so that your needs can be addressed. Disability Services determines accommodations based on documented disabilities in the academic environment, but please contact me to discuss how I can help even for conditions not on their list. Information on requesting accommodations is located on the Disability Services website. Contact Disability Services at 303–492–8671 or by email at dsinfo@colorado.edu for further assistance. If you have a temporary medical condition or injury, see the guidelines for Temporary Medical Conditions on the Disability Services website.

I try to provide a positive and supportive learning environment for everyone, and it's always helpful for me to hear what works best for you.

RELIGIOUS OBSERVANCES

Campus policy regarding religious observances requires that faculty make every effort to deal reasonably and fairly with all students who, because of religious obligations, have conflicts with scheduled exams, assignments, or required attendance. For full details, see the campus policy regarding religious observances.

MISCONDUCT, DISCRIMINATION, HARASSMENT, AND/OR RETALIATION

CU Boulder is committed to fostering an inclusive and welcoming learning, working, and living environment. The university will not tolerate acts of sexual misconduct (harassment, exploitation, and assault), intimate partner violence (dating or domestic violence), stalking, or protected-class discrimination or harassment by members of our community. Individuals who believe they have been subject to misconduct or retaliatory actions for reporting a concern should contact the Office of Institutional Equity and Compliance (OIEC) at 303–492–2127 or by email at cureport@colorado.edu. Information about university policies, reporting options, and other support resources can be found on the OIEC website. Please know that faculty and instructors have a responsibility to inform OIEC when made aware of incidents of sexual misconduct, dating and domestic violence, stalking, discrimination, harassment and/or related retaliation, to ensure that individuals impacted receive information about their rights, support resources, and reporting options. To learn more about reporting and support options for a variety of concerns, visit Don't Ignore It.

PREFERRED STUDENT NAMES AND PRONOUNS

CU Boulder recognizes that students' legal information doesn't always align with how they identify. Students may update their preferred names and pronouns via the student portal; those preferred names and pronouns are listed on instructors' class rosters. In the absence of such updates, the name that appears on the class roster is the student's legal name.

CLASSROOM BEHAVIOR

Both students and faculty are responsible for maintaining an appropriate learning environment in all instructional settings, whether in person, remote, or online. Those who fail to adhere to such behavioral standards may be subject to discipline. Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with race, color, national origin, sex, pregnancy, age, disability, creed, religion, sexual orientation, gender identity, gender expression, veteran status, political affiliation or political philosophy. For more information, see the policies on classroom behavior and the Student Conduct & Conflict Resolution policies.

The policy of the Department of Astrophysical and Planetary Sciences is to ban any use of electronic devices (cellphones, tablets, laptops) in class except as an approved accommodation granted by Disability Services, or as explicitly authorized by the instructor. *In this course* I authorize the use of tablets and laptops for note-taking, but in-person students doing so must do their best to seat themselves with nobody behind them.

REQUIREMENTS FOR COVID–19

As a matter of public health and safety, all members of the CU Boulder community and all visitors to campus must follow university, department, and building requirements and all public health orders in place to reduce the risk of spreading infectious disease. Students who fail to adhere to these requirements will be asked to leave class, and students who do not leave class when asked or who refuse to comply with these requirements will be referred to Student Conduct and Conflict Resolution. For more information, see the policy on classroom behavior and the Student Code of Conduct. If you require accommodation because a disability prevents you from fulfilling these safety measures, please follow the steps in the "Accommodation for Disabilities" statement on this syllabus.

CU Boulder currently requires masks in classrooms and laboratories regardless of vaccination status. This requirement is a precaution to supplement CU Boulder's COVID-19 vaccine requirement. Exemptions include individuals who cannot medically tolerate a face covering, as well as those who are hearing-impaired or otherwise disabled or who are communicating with someone who is hearing-impaired or otherwise disabled and where the ability to see the mouth is essential to communication. If you qualify for a mask-related accommodation, please follow the steps in the "Accommodation for Disabilities" statement on this syllabus. In addition, vaccinated instructional faculty who are engaged in an indoor instructional activity and are separated by at least 6 feet from the nearest person are exempt from wearing masks if they so choose.

If you feel ill and think you might have COVID-19, if you have tested positive for COVID-19, or if you are unvaccinated or partially vaccinated and have been in close contact with someone who has COVID-19, you should stay home and follow the further guidance of the Public Health Office (contacttracing@colorado.edu). If you are fully vaccinated and have been in close contact with someone who has COVID-19, you do not need to stay home; rather, you should self-monitor for symptoms and follow the further guidance of the Public Health Office (contacttracing@colorado.edu).