

First, a few words about the **big picture** of what we're doing. Our individual pursuit of knowledge and understanding in this seminar is happening in the larger context of our own lives and in the larger context of our collective activity both in the seminar room and outside of it. Science and science learning is a human and cultural practice and is – I believe – one of the best, most positive elements of our civilization. It is a *collective* social activity, not a pristine intellectual activity that happens only inside the heads of individuals. For each of us to succeed and benefit from our learning, the focus has to be collective. It has to be on all of us learning – and teaching each other – together.

The history of science as a field, including astronomy, has been embedded in a culture that exploits resources and people and frequently develops and uses technology for war-making and social control. Participating in science has historically come along with a lot of social status and access to resources and so science has historically been exclusionary and a bulwark of established power. Examples from astronomy include everything from the fact that the telescope was not used for astronomical observations until several decades after its invention for use in naval warfare; our new understanding in the 1920s that nuclear reactions power stars lead directly to the development of nuclear weapons that were used – twice – against civilian populations just two decades later; and today, on Mauna Kea, indigenous people are protesting the building of a large telescope on the mountaintop that several times previously had its “last” telescope built on it. At the level of the practitioner, for most of the 20th Century, only white men had access to the best research telescopes in the United States. Legendary astrophysicist and discoverer of dark matter, Vera Rubin, despite being a privileged upper middle class white woman, needed special, written permission from a more senior male astronomer in order to use the Palomar telescope in California in the early 1960s simply because she was a woman!

At some basic level, exclusion and discrimination are about power and access to resources. Being part of the scientific community has many benefits, and so it is vital that everyone has equal access to the opportunity to participate in it.

I think it's important for us each to think about how the history and current culture of astronomy and science, as it relates to issues of power and access, affects each of us, our seminar, and the department. Let's work together to create an environment in the seminar that's generous and supportive as we all strive together to do something hard but rewarding – learning about the physics of the interstellar medium – and do it well and rigorously. We will each benefit individually if we succeed in creating an environment that is strengthened by the fact that we each have come from different backgrounds, had and had access to different experiences and opportunities, have different outlooks and approaches, and that some of us are seniors with a lot of experience in seminars and others are juniors taking their first seminars.

If you are a person who likes to talk in class, I'd ask you to hang back a little, and if you're a person who is reluctant to talk, I'd ask you to make the effort to talk more. If we're discussing material that you happen to have seen before, please take the opportunity to solidify and deepen your understanding. That might be enabled by generously helping a student who has never seen that material before. And if something is new to you or you're having trouble remembering or applying something you know you have seen before, please make the effort to ask your questions and know that other people in the seminar are benefitting from hearing your questions.

Okay, on to the material and specifics of the seminar. You will be introduced to a lot of interesting phenomena and objects this semester as we **study the interstellar medium together**. You'll find a pleasing synthesis of many physics and astrophysics concepts you've been learning and thinking about the last few years. And you'll also be introduced to open research problems and read research and review papers. You'll be asked to think of questions as answerable but often open-ended. Your problem solving skills will be tested, and you'll

be expected to provide qualitative (and sometimes quantitative) interpretation of the solutions you come up with, both in writing and verbally, in seminar.

My goal for each of you is to help you increase both your knowledge and your reasoning and communication abilities and strategies. And to help you work collaboratively with your classmates to gain – and help them gain – this understanding.

To these ends, you will each be relying on each other to present and explain the material we read about each week. You will have to have the desire and discipline to read carefully the material I assign and to think about it – always testing your own knowledge and incomplete understanding. I will be counting on you to ask good and productive questions about the material we read each week. And that will require giving yourself enough time to read, think, re-read, and answer questions. To maximize your happiness and learning, you absolutely must start working on the week's assignment more than 48 hours ahead of time. And you must read the material more than once, after thinking about the questions I ask in the week's assignment.

You should access other resources to look things up. Wikipedia is not always bad when it comes to astro, physics, and math. You should talk to each other and work together on the assignments (but always doing your own final writing, math, and coding). And you should feel comfortable asking me anything – after you've tried a few things yourself.

We will use a combination of textbooks, review articles, and other resources throughout the semester. Physical books will be on reserve in Cornell but I'll provide electronic versions of almost all reading I assign. There is currently no good, modern advanced undergraduate level ISM textbook. But the multiple perspectives we get from using multiple sources will be a positive experience, although switching back and forth between styles and even unit systems will take a bit of effort.

The weekly assignments will consist of a document that has information, suggestions for how to think about the concepts you're learning and connections among them, worked problems for you to solve and write up, and other questions/problems that you should be prepared to discuss in our seminar reading but which you don't have to write up solutions for. You may want to jot down some notes about them, though, to make it easier to discuss them in seminar.

I will designate some problems for you to solve and hand in your solutions to on the Monday before seminar. You should hand in the Monday problems on paper (sometimes I'll ask you to email me things – like code – too or instead, but the default hand-in mode should be paper). I will look them over and make comments and hand them back to you on Tuesday. I expect you then to read over my comments and do whatever additional thinking (and possibly note-making) is required in order to have adequate understanding for the discussion that will happen in seminar (i.e. we may go over some of those Monday problems in seminar on Wednesday, and you'd be expected to be able to present a good solution at the board even if your handed-in solution was not so good). I will have office hours from 11 to noon on Mondays to enable students to get last-minute help if they're finishing up those warm-up problems. And they'll generally be due in the early afternoon. Specific details will be provided with each week's assignment.

Other problems I'll expect you to hand in when you arrive in seminar on Wednesday at 1:15. We'll go over them, too, in seminar. You should xerox a copy of these problems to give me so that you also have a copy to mark up in seminar. At the end of seminar, you'll have made some notes/corrections/elaborations on the written work you brought to seminar. At that point, we'll decide on a couple of the week's problems that everyone will have a chance to redo and hand in formal solutions by the next day (or just stick with the work they've already handed in). I will grade (only) those problems each week, although I'll look over the xeroxed work each student handed in at the beginning of seminar.

As mentioned above, beyond the problems in each assignment for which you have to write up solutions (and hand in either on Monday or Wednesday), the assignment will have commentary – points to think about as you’re reading specific sections of the text, questions to answer (but not hand in solutions to), images to find, graphs to sketch. You should really address all the commentary – make sketches, jot down a few notes, find and share images. Expect to have a discussion in class about the reading, based on this commentary. It is your responsibility to be prepared for it. Addressing my commentary is a way for you to make sure you really have deep understanding of the material you’re reading. You will be able to tell the difference between this commentary and problems you should think about but don’t have to write up solutions to on the one hand, and problems you do have to write up solutions to on the other hand because the latter will be numbered and the former will be unnumbered.

Sometimes, I will supplement the formal problems with presentations, usually about that week’s reading. That is especially true when we read research articles and review articles, which we will do increasingly as the semester progresses. These presentations will probably be the only instances of assigned work that not every student does. Some seminars in our department have each student responsible for a subset of problems, but I feel things work better in my seminars when every student solves every problem before coming to seminar. We’ll have a sign-up at the beginning of our seminar meetings where students can decide which problems they’ll present. We’ll never embarrass students who don’t want to present a solution to a particular problem, but every student should make an honest effort to come to seminar with as complete a solution/answer as possible to each problem/question. And every student will have to present at least one of their solutions and commentary on it, each week.

I will “lightly” grade the problems you hand in on Mondays. That will be based on effort and thoroughness. We will have a midterm and a final exam. The grade breakdown will be roughly 50% weekly seminar work – both written and participation and presentation in seminar, 20% midterm, and 30% final exam.

OK! To summarize the weekly work flow: Thursday you optionally hand in re-writes of a couple of problems from the day before and you get the new assignment and start to read and think and look at the problems you need to solve and answer. Friday I will usually have office hours and you can come and talk about things you’re finding confusing. By Monday afternoon you’ve handed in a small number of warmup problem solutions. By Wednesday morning, you’ve got solid solutions and answers to all the rest of the problems, with write-ups of the numbered problems. On Wednesday afternoon you come to seminar, ready to discuss each problem, and thinking about which problem or two you’d like to present at the board.

Some rules/guidelines about seminar culture: You can bring laptops or tablets to seminar and use them. But it’s so easy to get distracted by things on the computer. Let’s acknowledge how weak we all are and be vigilant about using our electronics as productive learning tools only! I really don’t want people’s phones out in seminar. Bring a calculator each week to do simple calculations, check the arithmetic in your written work, etc. Calculation is an important part of astrophysical reasoning and learning. (In physics, things are often more abstract and simply getting a functional form but not plugging in numbers is what’s done, but in astrophysics, we more frequently are numerically evaluating expressions.) Please don’t leave the seminar room except during break. We want to create a focused and respectful and supportive environment in seminar. In our department, students generally call professors “Professor” before they are majors and then after they become majors (or minors) there is more flexibility. I’m very happy to have you each call me David, but if you’re more comfortable continuing to use “Professor Cohen” that’s fine with me and I’ll try to respond (e.g. in emails) in kind. Please don’t call me just “Professor” though! Finally, snack – we’ll have a rotating snack schedule. Because we have a lot of students in the class, I think each student will only have to bring snack once this semester. I am sensitive to the burden of having to buy a significant amount of food,

so please speak to me privately if the financial burden is excessive for you. However, I want to point out that students can use points at the Co-op to buy seminar snack. And I do think there's something positive about each of us having to take responsibility for the well-being and comfort of our classmates one week by doing the planning, buying the food, and presenting it. No one should feel compelled to buy fancy or expensive food. And there's no need to buy drinks at all (since we have water, cups, and usually some leftover juice or soda in the department kitchen from a recent event).