Summary and Course Objectives

This course aims to introduce you to research at the forefront on astrophysics, focusing on work carried out at the Harvard-Smithsonian Center for Astrophysics (CfA). The CfA is the research home of over 300 PhD astronomers who operate many of the most powerful astronomical observatories on the planet, and off of it! This course will provide you with the opportunity to discuss astrophysical research with leading scientists, and to undertake your own research project under the mentorship of one of these individuals. Just like in research, there are no problems sets or formal exams. Instead, we will focus on far more interesting skills and experiences, including developing your ability to:

- research and present topics that are initially unfamiliar to you,
- identify interesting unanswered questions in astronomy and to pursue them through novel investigations,
- explain the intermediate results of your own ongoing research to your peers,
- discuss the research of others in a constructive and engaging manner,
- give effective presentations, and,
- write a technical description of your findings.

Recognizing that science is a social endeavor, our meetings with CfA scientists are intended not only to enable a discussion of the science at hand, but also offer a chance to chat more broadly about the career path that each of these individuals has chosen in astronomy. Since you may have already begun to consider your plans beyond college, we will include meetings not only with research scientists but with individuals who work in science education, public relations, science policy, and science journalism, with the goal of illuminating some of the available options. I will also arrange meetings with graduate students and members of graduate admission committees, as some of you may be considering an advanced degree in the physical sciences.

I am very excited about this tutorial, and will work very hard to attain our goals and make this course a rewarding experience for you. I will make myself as accessible as possible, so please email, call, or stop by my office anytime.

Prof. David Charbonneau
Thomas D. Cabot Associate Professor of Astronomy
Director of Undergraduate Studies, Astronomy & Astrophysics

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Course Structure

Enrollment is limited to 10 students. This course has two related elements, which run simultaneously throughout the semester:

First component: Weekly Science Discussions.

We will meet Wednesday evenings for a dinner conversation with an invited speaker. We will get food from the Pforzheimer dining hall and bring it upstairs to the Moors 2 meeting room. The week before each dinner meeting, the speaker will assign a reading, which will be distributed through the course webpage. We will discuss this reading at our Monday afternoon meeting prior to the Wednesday dinner, and so you are expected to complete the reading by 3pm Monday. Students will take turns leading these sessions, which will generally begin with a review of the assigned reading, followed by a group discussion. The second half of the Monday afternoon sessions will be used for informal chats with invited guests (including science journalists, educators, individuals working in science policy and public relations, and graduate students and faculty in astrophysics), and for more structured discussions of the ongoing research of the class members.

Calendar of Dinner Gatherings  Wednesdays 5:30 – 7:30 pm, Pforzheimer House, Moors 2

<table>
<thead>
<tr>
<th>Date</th>
<th>Speaker</th>
<th>Topic</th>
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<tr>
<td>January 28th</td>
<td>Introductory Meeting</td>
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<tr>
<td>February 4th</td>
<td>Rosanne Di Stefano</td>
<td>Hunting for Exoplanets with Einstein’s Help</td>
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<td>February 11th</td>
<td>Matthew Holman</td>
<td>Finding Outer Solar System Binaries with Pan-STARRS-1</td>
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<td>February 18th</td>
<td>Brief presentations of proposed research by all students.</td>
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<td>February 25th</td>
<td>Robert Kirshner</td>
<td>From the Crab Nebula to the Accelerating Universe: Supernovae I Have Known</td>
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<td>March 4th</td>
<td>Jonathan Grindlay</td>
<td>How to Survey the First Black Holes to EXIST</td>
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<tr>
<td>March 11th</td>
<td>Dimitar Sasselov</td>
<td>Super-Earths: Exploring a New Type of Planet</td>
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<td>March 18th</td>
<td>Robert Naeye</td>
<td>Editor-in-Chief, Sky &amp; Telescope</td>
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<td>March 25th</td>
<td>Spring Recess – No Meeting</td>
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<td>April 1st</td>
<td>Christine Jones</td>
<td>Reflections of Outbursts from Supermassive Black Holes</td>
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<td>April 8th</td>
<td>Philip Sadler</td>
<td>An Astronomical Education</td>
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<td>April 15th</td>
<td>Edo Berger</td>
<td>Pan-STARRS: A New Eye on the Transient Sky</td>
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<td>April 22nd</td>
<td>Julia Lee</td>
<td>Black Holes in the Violent Universe</td>
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<td>April 29th</td>
<td>Avi Loeb</td>
<td>The Lonely Future of Our Universe</td>
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Second Component: Independent Research Project.

Throughout the semester, you will pursue an independent research project in astrophysics under the mentorship of a CfA scientist. The schedule for this portion of the course is given below. It is vital that you meet frequently with your advisor, and with rare exceptions these meetings should occur at least once a week. Note that in many cases, students later call upon their mentors to write letters of recommendation, and many students have continued the research projects initially begun during Astronomy 98 into the subsequent summer or future semesters. The department offers an award for outstanding research projects completed in Astronomy 98.

Important Dates Concerning Your Research Project

No later than February 1st Email 3 – 5 CfA scientists to inquire about a research project, and set up times to meet asap, and no later than February 11th. You must meet with at least 2, and preferably 3 potential mentors prior to settling on a project. Lists of CfA scientists and summaries of their research will be available at the course website.

Wednesday, February 11th Submit a 1-page summary of your discussions with the CfA scientists. This should describe whom you met and what you discussed, and give your thoughts on the options. This can be submitted either as a hardcopy at the evening meeting, or by email to Prof. Charbonneau prior to that meeting.

Wednesday, February 18th Submit a hardcopy 1-page description of your proposed research project, signed by your research advisor. Ideally this document should also state the times of your planned weekly meetings with your advisor. Each student will give a brief presentation of her or his proposed project.

February – April Students will periodically give updates on their ongoing work during the Monday afternoon sessions.

Wednesday, April 8th Submit a preliminary abstract for your research paper by email to Prof. Charbonneau and your mentor. Primary research activities should be largely completed, and you should now focus on writing the description of your work.

Wednesday, April 29th Complete draft of research paper submitted to Prof. Charbonneau and your research advisor for comments.

May 6th (Tentative) Presentation of your research to the class and CfA scientists.

May 11th (Tentative) Submission of final version of research paper, incorporating any comments received during the oral presentation.
Course Meeting Times and Locations

The course meets Mondays 3 – 4:30pm in the Tea Room (P-226) at the Center for Astrophysics at 60 Garden Street near the Quad, and from 5:30 – 7:30pm in the Moors 2 room at Pforzheimer House. Maps of these locations are available at the course website. Class will not meet February 16th, March 23rd, or March 25th, which are University holidays.

Course Webpage

http://isites.harvard.edu/k53484

Grading

Weekly Science Discussions:

Students will be asked to take turns leading the Monday discussions of the preparatory readings. This will generally involve a brief presentation followed by a group discussion. You will receive credit for giving well-prepared, clear, and engaging summaries of the readings, and leading the resulting discussion in an effective and inclusive manner. 20%

You are expected to attend all of the Monday and Wednesday meetings and to participate fully in the discussions. You will receive credit for this participation, for demonstrating that you have completed the reading, and for volunteering ideas and asking questions that stimulate the discussion. 20%

Independent Research Project:

Since it is vital to develop your ability and confidence to describe your research at intermediate stages, you will receive credit for giving brief summaries of your work at several points throughout the semester. These are important opportunities to solicit the input of your classmates. Ideally, their suggestions will refine your thinking and help to push your work in unanticipated directions. You will also receive credit for the brief written summaries that you will submit February 11th and February 18th, in which you describe how you chose your project, and for the preliminary abstract describing your findings that you will submit April 8th. 10%

It is equally important to take an active interest in the research of others, to learn to think critically about it, to share your thoughts in a constructive manner, and to offer your suggestions for future work they might pursue. You will receive credit for the quality of your participation in the Monday discussions of the work of your classmates. 10%

At the end of the semester, you will submit a final written description of your research. This should follow a format of a scientific paper, and include a summary of the state of knowledge in the topic, the motivation of the question you will address, a description of the data and methods used in the analysis, a discussion and critique of your results, and your conclusions. During reading period, we will convene an afternoon session at which all students will present their work to their classmates and CfA scientists. 40%