

Special Topics in Theoretical Astrophysics

Syllabus for Spring 2019

Organizer: Xuening Bai (IASTU & THCA)

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Office: THCA — Mong Man-wai Building (蒙民伟科技楼) S-617

IASTU — Science Hall (科学馆) 312

Instructors: THCA faculty members

Time: Fridays, 3:00-4:30 pm

Location: Mong Man-wai Building (蒙民伟科技楼) S-727

Office Hours: Walk-in or by appointment.

Format

THCA students will take turns to give review talks on certain topics assigned to them. The topics follow from a general theme, decided and compiled by the organizer. For each topic, a few references are suggested as the starting point based on which students will construct their talks. We stress that students should **select topics that are different from their current research topics**. There is a faculty contact to help with preparation.

Students are expected to read the references associated with their assigned topics, and are encouraged to explore other relevant literature as needed. For theoretical topics, **a good practice is to start preparing the talk three+ weeks ahead of time**. During the preparation, students should feel free to consult with the organizer and/or faculty contact for guidance and assistance. **At least two days before the talk, the student must get ready and discuss with the faculty contact for approval**. If approved, the faculty contact will further comment and help improve the presentation, and the student should further practice and polish the talk. **If not approved, the talk will be cancelled**. For graduate students, this not only means that you lose the opportunity to improve your presentation skills, but also, you will no longer be eligible for THCA scholarships.

Each presentation is expected to be 25 minutes for the talk, plus 5 minutes for questions. We require every presenter to **give the talk in English**. English is also strongly encouraged during the question session, but it is OK to switch to Chinese if necessary.

Participation and Enrollment Policy

This course is part of the standard astrophysics curriculum at THCA. We require all THCA graduate students to *participate* in the course unless this is the year for graduation. However, the online system only allows one to enroll a course once. To avoid conflict, we ask graduate students to **enroll only when it is the last time he/she is going to participate in this course**. On the other hand, we do record the performance of all students, and grading will also be based on previous performance.

Graduate students are excused for not participating in this course when he/she is on leave (e.g., attending exchange programs abroad for extended period), or this is his/her final semester (for thesis defense).

Senior (4th yr) undergrad students are strongly encouraged to participate and give presentations, but we welcome anyone interested to attend the talks. You are also welcome to enroll in the course if you are **NOT** planning to enter THCA for graduate school.

Evaluation and Grading

The faculty contact will judge the overall quality of the talk based on the level of understandings the student possesses on the topic, and how well the talk is prepared. **The bottom line is that an audience with no background on the topic should be able to learn something useful from talk.**

Some guiding principles include:

- 1). The content of the talk is reasonably well organized and joined in a logical way. It should contain introduction, method, results, and summary sections, and please also pay attention to the transition between slides.
- 2). Be confident about all the information you show in each slide. Don't simply read the slides, but rather explain the content, discuss the implications, and highlight the key results.
- 3). Be able to answer basic questions that may arise from anywhere in your slides and/or your words.

The nature of this course means that students themselves are primarily responsible for their performances: the more you invest in preparing your talk, the more you will learn and grow. While grading will be judged according to the history of performances on a P/F basis, we do not easily fail anyone unless his/her performance is exceptionally unacceptable.

Theme of the Semester: Plasma Astrophysics

Plasma pervades the universe at all measurable scales. Most visible matter, from the Earth's outer atmosphere to the intracluster medium between galaxies, is magnetized and ionized. Plasma physics effects can be pivotal in determining the flow of mass, momentum, and energy in essentially all astrophysical systems. For example, magnetic fields convert kinetic energy from stellar interiors to heat their outer atmospheres. Magnetic fields tap the rotational energy of accretion disks to drive jets and outflows, and plasma transport processes determine the rates of accretion onto stars and black holes. In supernova remnants and the interstellar medium, magnetic fields oppose the tendency of plasmas to thermalize by accelerating cosmic rays, and such cosmic-rays stream and diffuse away from the galaxy which also serve as important feedback to background galaxies and beyond.

This semester, we survey the major applications of plasma physics in astrophysics through a series of theoretical topics, which include dynamo theory, solar and space physics, origin and propagation of cosmic rays, magnetic reconnection, turbulence, accretion disks, and weakly collisional plasmas. We also briefly cover certain laboratory plasma experiments.

Given that most of the students have no background in plasma physics, the topics for this semester are likely substantially more challenging than those in the past. It is thus highly recommended to start the preparation as early as possible. Some of the plasma astrophysics basics will be covered in the introductory lecture, whereas more topic-specific background needs to be studied on your own. You are welcome to consult the organizer, Prof. Bai, for science-related questions, whereas the assigned faculty contact are more responsible for your presentation.

The references provided for each topic can be review talks, individual papers, or a combination of both. Please note that the number/length of the papers/articles provided do not necessarily reflect how difficult they are. Therefore, please choose the topics mainly based on your interest, and it is strongly encouraged to open up your mind and explore something entirely new.