Spring 2022

PHYS 728-002: Radio Astronomy

Bin Chen

Course Syllabus

Edit

Phys 728: Radio Astronomy (Spring 2022)

This course is an introduction to radio emission processes, radiative transfer, radio diagnostics, and radio instrumentation. Topics also include radio flux measurements with single-dish antenna, radio imaging with interferometer arrays (Fourier-Transform-based imaging), and image reconstruction techniques. Application is to astronomical objects with special emphasis on the Sun.

The classes will be held online via Webex until Jan 30. After that, the classes will be held fully in person. For all in-person classes, all students must attend in-person unless they have a special accommodation granted by the instructor or the Dean of Students. Students **are required to wear a mask** in the classroom. Students failing to observe the mask mandate will be asked to leave the classroom. Because of the current situation, **eating is *not* permitted in the classroom (drinking is permitted)**. Please refer to NJIT's **Pandemic Recovery website** (https://www.njit.edu/pandemicrecovery/) for the most up-to-date guidelines and rules relevant to COVID-19.

Course Information

Time: 11:30 am - 12:50 pm, Tuesdays and Thursdays

Location: In-person classes: Faculty Memorial Hall, Room 319; Online classes: see WebEx link in the Canvas announcement.

Instructor: Prof. Bin Chen. Email: **bin.chen@njit.edu** (mailto:bin.chen@njit.edu). Web: **https://web.njit.edu/~binchen** (https://web.njit.edu/~binchen)

Office Hour and Location: Wednesdays 2–3 pm or by appointment; Tiernan Hall Room 101.

Main Textbook: **Essential Radio Astronomy** (https://science.nrao.edu/opportunities/courses/era) by Condon & Ransom. The book is **an open-access textbook**, available online for free. A hard copy of the textbook is also available (e.g., **Amazon** (https://www.amazon.com/Essential-Astronomy-Princeton-Modern-Observational/dp/069113779X)), but it is not required.

Other Materials: The other main resources we will use are the lecture notes in the textbook **Synthesis Imaging in Radio Astronomy II** (https://www.aspbooks.org/a/volumes/table_of_contents/?book_id=292) (edited by G. B. Taylor, C. L. Carilli, and R. A. Perley) and those on **Prof. Dale Gary's Phys728 website** (https://web.njit.edu/~gary/728/). We will use tools including **CASA (Common Astronomy Software Applications)** (https://casa.nrao.edu/index.shtml) for creating, calibrating, and analyzing radio data, and **Python** (https://www.python.org/) for general-purpose programming and as a scripting interface to these tools. Note that Python has many extension packages, which you can install

yourself, or alternatively you can download the **Anaconda Python (https://www.anaconda.com/products/individual)** pre-packaged distribution for scientific computing.

Prerequisites: Working knowledge of classical mechanics, macroscopic thermodynamics, electromagnetism, elementary quantum mechanics, and basic astrophysics. Advanced knowledge of electromagnetism with vector calculus, electrical engineering, special relativity, statistical thermodynamics, advanced quantum mechanics, or advanced astrophysics is *not* required. Students who do not meet the official pre-requisites (PHYS 621 and PHYS 641 or the equivalent) should contact the course instructor for approval.

Homework Assignments

The homework assignments will be posted via Canvas. They are **typically** due each Thursday by the time of the lecture (11:30 am) but **pay close attention to the specific due dates posted with each assignment**. You should submit either a text response or upload a file (preferably in pdf, but doc, docx, or pages also accepted), so check the assignment early and be prepared. **All the homework submissions must be done on Canvas**.

Late submissions for homework assignments are strongly discouraged. They **will only receive 50% of the original points**. All the **late submissions need to be submitted prior to the end of the reading day (May 5) to receive *any* credits**.

Class Project

There will be a class project. The topic is to design your own (virtual) radio telescope array for solar observing, using tools available in Python and CASA. Students are expected to work in pairs. Each group will present its results/findings toward the end of the semester. A written report is also required as part of the project outcomes. The grades of the project are determined by the quality of the **presentation AND the written report**. The students forming each group will receive the same grade. So be sure to collaborate with each other and have frequent interactions. Detailed discussions/tutorials will be available during the semester.

Exam

There will be a **final exam** during the exam week. All the exams will be carried out **in person** unless you have received special accommodation from the **Dean of Students (https://www.njit.edu/dos/)**. **Makeup exams** will only be allowed **under extenuating circumstances** such as severe illness. Students with such requests must contact the **Dean of Students (https://www.njit.edu/dos/)** for approval. They will be making the determination of whether extenuating circumstances exist or not and will be notifying the instructor (me) accordingly. Note I will never request or accept medical or other documents from students; such documents need to be submitted by the student to the **Dean of Students (http://njit.edu/dos/)**.

Grades

Your grade will be based on your homework assignments (35%), class project (30%), attendance and class participation (5%), and final exam (30%).

Statement on academic integrity

Academic Integrity is the cornerstone of higher education and is central to the ideals of this course and the university. Cheating is strictly prohibited and devalues the degree that you are working on. As a member of the NJIT community, it is your responsibility to protect your educational investment by knowing and following the academic code of integrity policy that is found at: http://www5.njit.edu/policies/sites/policies/files/academic-integrity-code.pdf (https://t.e2ma.net/click/7xcjqfb/rxlloovf/vc0hkjx) .

Please note that it is my professional obligation and responsibility to report any academic misconduct to the Dean of Students Office. ***Any student found in violation of the code by cheating, plagiarizing or using any online software inappropriately will result in disciplinary action. This may include a failing grade of F, and/or suspension or dismissal from the university.*** *If you have any questions about the code of Academic Integrity, please contact the Dean of Students Office at* ***dos@njit.edu*** **(mailto:dos@njit.edu)**

Tentative Schedule

For reference purposes, the following is a ***tentative*** schedule on which we will discuss specific topics. Please refer to the Modules section on Canvas for the most up-to-date schedule and topics.

Week 1 (Jan 17): Introduction

Week 2 (Jan 24): Radiation Fundamentals I

Week 3 (Jan 31): Radiation Fundamentals II; Fourlier Transforms

Week 4 (Feb 7): Antenna Fundamentals, Refractor Antennas

Week 5 (Feb 14): Radio Telescopes, Radiometers, and Receivers

Week 6 (Feb 21): Fundamentals of Radio Interferometry

Week 7 (Feb 28): Synthesis Imaging and Deconvolution

Week 8 (March 7): Class Project Discussion: design your own radio telescope array

Week 9 (March 14): No class (spring break)

Week 10 (March 21): Radio Emission Mechanisms I

Week 11 (March 28): Radio Emission Mechanisms II

Week 12 (April 4): Special Topics - Terrestrial Radio Research

Weeks 13-14 (April 11 & April 18): Special Topics - Solar Radio Astronomy

Week 15 (April 25): Class Project Presentations

Week 16 (May 2): Reading Days and Final Exam (date TBD)