DEPARTMENT OF PHYSICS & ASTRONOMY

TEXAS TECH
College of Arts & Sciences

ASTR 3300 / PHYS 5300 Special Topics in Astrophysics

Radio Astronomy Spring 2026

SCHEDULE

2:00 – 3:20 pm TR at Sci 204

INSTRUCTOR

Dr. Emilia Järvelä | Sci 114 | ejarvela@ttu.edu
Office hours: 3:20 – 4:30 pm TR or by appointment

DESCRIPTION

This is a 3cr course on radio astronomy, a relatively new field of astronomy – not even a hundred years old! The course will go over the basics of radio emission, astrophysical sources that emit in the radio band, instrumentation used in radio astronomy, as well as data reduction, analysis and interpretation. During this course, the students will have opportunity to visit the Karl G. Jansky Very Large Array in person.

LEARNING OUTCOMES AND TOPICS

After this course the student
- can summarise the role that radio astronomy plays in our quest to study the Universe.
- can explain how the radio sky, local and high-redshift, looks at different frequencies, and what the emission and absorption mechanisms producing the observed characteristics of radio emission are.
- is able to sketch the fundamentals of radio antennas and arrays, and can compare their differences.
- can outline the principles of interferometry and aperture synthesis.
- is able to calibrate, reduce, and analyse interferometric data using Common Astronomy Software Applications (CASA), and interpret the results.
- can present her/his results verbally and by means of writing using a scientific style.
- can identify the challenges radio astronomy is facing, and the scientific community's attempts to mitigate these issues.
- can explain the future developments in the field, and the unprecedented possibilities the next generation radio telescopes and arrays offer.

Key topics of the course are
- Fundamentals of radio astronomy
- Radio emission and absorption mechanisms
- Galactic and extragalactic radio sources, cosmic microwave background
- Radio antennas and receivers
- Single-dish radio astronomy
- Interferometry and aperture synthesis
- Challenges of radio astronomy
- Future of radio astronomy
- Calibration, reduction, and analysis of radio data obtained with the JVLA
- Data interpretation and writing a scientific report

COURSE PREREQUISITES

There are no prerequisites for this class, but the basics of calculus will be useful.

RESOURCES

All resources are available for free or via TTU Libraries. Additional resources will be included in the lecture slides and/or RaiderCanvas.

Tools of Radio Astronomy by Wilson, Rohlfs, and Hüttemeister
- Available through TTU SSO here.

Essential Radio Astronomy by Condon and Ransom
- Freely available here.

Interferometry and Synthesis in Radio Astronomy by Thompson, Moran, and Swenson
- Available through TTU SSO here.

WEB TOOLS

RaiderCanvas. The course web page is on RaiderCanvas. Course announcements will be posted on this site, but for anything extra important I will also send an email. RaiderCanvas will also be used for electronic communications, and to post other relevant course material (such as lecture notes, grades, homework assignments etc.). Please check RaiderCanvas and your Texas Tech email at least once a day to ensure you are not missing important course information.

LECTURES

Lectures are in person. Attendance is not mandatory, but I recommend attending lectures as much as you can - attendance and grades tend to be correlated. I will post my slides on RaiderCanvas in case you miss a lecture. All course materials may only be accessed through the RaiderCanvas course page by legitimately enrolled students. No copying or distribution is allowed without the prior permission or consent of the instructor.

FIELD TRIP TO THE KARL G. JANSKY VERY LARGE ARRAY AND NRAO

During this course, the students will have an opportunity to visit the Very Large Array and the National Radio Astronomy Observatory in Socorro, NM. The trip is not mandatory and does not have an impact on the final grade. The date will be decided later, based on the interested students' schedules.

KARL G. JANSKY VERY LARGE ARRAY PROJECT

During this course, the students, as 2-3 groups, will propose for JVLA observations, and prepare the scheduling blocks for the observations. They will also learn how to calibrate the data using a pipeline, produce CLEANed radio maps, and analyse and interpret them. For the project, every student will individually write a scientific report (10 pages, including figures and references), that is worth of 20% of the final grade. The presentation about the project, delivered as a group, will be worth 10% of the final grade.

REVIEW PAPER

Another 20% of the final grade will be determined based on a review paper. You are free to choose any topic related to radio astronomy, but it needs to be approved by the instructor. The paper should be 5-6 pages, and summarise our current knowledge of the topic using 15-20 peer-reviewed references. Further instructions will be given during the course.

HOMEWORK

Homework is due every other week. You can check the exact due dates from the course schedule. Homework accounts for 30% of your final grade. Homework assignments will be posted on RaiderCanvas, and can be returned on paper or via email.

EXAMS

We will have one midterm exam and no final exam, but presentations of the JVLA project instead. The midterm and the presentations will be in person.

Midterm. The midterm grade will be worth of 20% of the final course grade. The midterm exam will cover material up to the date of that exam. The date can be found in the schedule.

Final presentations. There will be no final exam. Instead, the exam slot will be used to deliver presentations about the JVLA project completed during the course. The presentation will be worth 10% of your grade. You can find the date in the schedule.

TTU's policy regarding final exams states:

- All final exams must be given at the assigned time. They may not be given prior to the officially assigned time.
- If a student misses their final exam, they must contact their instructor. This is a matter between the student and the instructor. The policy for this class is that no make-up final exams will be given except in the event of severe documented illness requiring hospitalisation on the day of the final exam.
- There is no policy on how many final exams a student can have in one day. Students should check the Final Examination Schedule (posted in the Schedule of Classes) prior to registration to avoid an inconvenient overload during final exams. Click here for more info about the final exam policy.

MAKE-UP EXAMS

A make-up exam for the midterm will be administered in the case of a documented university-sponsored activity with a minimum of 48 hours advance notice, documented military service or a death of an immediate family member or grandparent. The only other circumstances that will compel the administration of a make-up exam is a documented medical emergency or another documented incapacitating medical condition that renders the student unable to take the exam at the scheduled time. In either case, the student will be given full opportunity to earn full credit for a missed assignment. A medical emergency is defined as a documented visit to a hospital emergency room or admission to an inpatient facility. Outpatient doctor's appointments and non-emergency visits to an urgent care clinic do NOT constitute a medical emergency and will not compel the administration of a full credit make-up exam. All medical documentation must be date and time-stamped.

ASSESSMENT AND GRADING

Students' understanding of the learning goals will be evaluated from selected questions on homework assignments, the midterm exam, the project reports and related presentations, and the review paper. The final grade is composed of the following fractions: homework at **30%**, midterm exam at **20%**, project report at **20%**, project presentation at **10%**, and review paper at **20%**. The thresholds for letter grades are 90% for A, 80% for B, 70% for C, and 60% for D.

ILLNESS-BASED ABSENCE POLICY

If at any time during this semester you feel ill, in the interest of your own health and safety as well as the health and safety of your instructors and classmates, you are encouraged not to attend face-to-face class meetings or events. When you return and once you have provided proper documentation, we will make arrangements for missed work on an individual basis. All medical documentation must be date and time-stamped. In case of an illness that will require absence from class for more than one week, the student should notify his or her Academic Dean.

AI USE

In this course, generative AI use is permitted for assistance, not authorship. Artificial intelligence applications, including but not limited to ChatGPT, Claude, Gemini, DALL·E, Grammarly, or similar applications, may be used to assist with specific tasks such as submitting a first draft to a generative AI application to assist with refining or evaluating original student-produced work, such as grammar or sentence structure assistance. Students are expected to apply what they are learning in this course to author work for this class—drawing on their own developing knowledge, understanding, and skills. Using generative AI as a collaborator means that a student is not simply copying or submitting AI-generated work but is actively engaging with the AI tool as part of the creative or problem-solving process. Transactional use—uploading assignment instructions and then submitting the AI-generated result as your own—is prohibited and may constitute a violation of academic integrity which may be referred to the Office of Student Conduct. When using AI in permitted contexts as outlined in the syllabus or explicitly permitted by the instructor, you are responsible for ensuring that AI-generated content is properly cited, accurate, ethical, free of misinformation or intellectual property violations. AI-generated content must never be submitted as your own work. Doing so may constitute a violation of academic integrity and may be referred to the Office of Student Conduct. Please contact me if you have questions regarding this course policy.

Any generative AI use should be cited AND clearly disclosed according to the instructions in this syllabus. An example of an APA citation (7th ed. format) is seen here: OpenAI. (2025). ChatGPT (May 2024 version) [Large language model]. https://chat.openai.com

DISTRIBUTION OF COURSE MATERIALS

All course materials students receive or to which students have online access are protected by copyright laws. Students may use course materials and make copies for their own use as needed, but unauthorised distribution and/or uploading of materials without the instructor's express permission is strictly prohibited. Students who engage in the unauthorised distribution of copyrighted materials may be held in violation of the University's Code of Conduct and/or liable under Federal and State laws.

STATEMENTS REQUIRED BY TTU can be found here.

CIVILITY IN THE CLASSROOM STATEMENT

Texas Tech University is a community of faculty, students, and staff that enjoys an expectation of cooperation, professionalism, and civility during the conduct of all forms of university business, including the conduct of student-student and student-faculty interactions in and out of the classroom. Further, the classroom is a setting in which an exchange of ideas and creative thinking should be encouraged and where intellectual growth and development are fostered. Students who disrupt this classroom mission by rude, sarcastic, threatening, abusive or obscene language and/or behaviour will be subject to appropriate sanctions according to university policy. Likewise, faculty members are expected to maintain the highest standards of professionalism in all interactions with all constituents of the university (www.depts.ttu.edu/ethics/matadorchallenge/ethicalprinciples.php).

SCHEDULE

(tentative, likely to change)

Lecture	Topics	Homework
R Jan. 15	Welcome to radio!	
T Jan. 20	Emission mechanisms	
R Jan. 22	Emission mechanisms	HW #1 opens
T Jan. 27	Absorption mechanisms	
R Jan. 29	Galactic radio sources	
T Feb. 3	Galactic radio sources	
R Feb. 5	Extragalactic radio sources	HW #1 due, HW #2 opens
T Feb. 10	Extragalactic radio sources	
R Feb. 12	Cosmic microwave background	
T Feb. 17	Writing a scientific report	
R Feb. 19	Antennas and receivers	HW #2 due, HW #3 opens
T Feb. 24	Antennas and receivers	
R Feb. 26	Single-dish antennas	
T Mar. 3	Single-dish antennas	
R Mar. 5	Interferometry	HW #3 due, HW #4 opens
T Mar. 10	Interferometry	
R Mar. 12	Midterm	
T Mar. 17	Spring break!	
R Mar. 19	Spring break!	
T Mar. 24	Aperture synthesis and imaging	
R Mar. 26	Introduction to the JVLA	HW #4 due, HW #5 opens
T Mar. 31	Choosing the projects	
R Apr. 2	Choosing the projects	
T Apr. 7	Challenges of radio astronomy	
R Apr. 9	Data calibration	HW #5 due, HW #6 opens
T Apr. 14	Data reduction	
R Apr. 16	Data analysis	Review paper due
T Apr. 21	Data analysis	
R Apr. 23	Data analysis	HW #6 due
T Apr. 28	Interpreting results	
R Apr. 30	Interpreting results	
T May 5	Future of radio astronomy	JVLA report due
S May 9	Final presentations	