PTYS 516

Asteroids, Comets, and KBOs

Fall 2026 Syllabus

Instructor: Prof. Vishnu Reddy, vishnureddy@arizona.edu, Kuiper 233

Office Hours: Monday 12:00-2:00 pm; Wednesday 12:00-2:00 pm; and by appointment

Class Hours: 75-minute in-person class Mondays and Tuesdays from 2:00 pm to 3:15 pm in Kuiper 330; Additional observing sessions will require participation after class hours as described in the syllabus or outlined by the instructor.

Course Format: Literature seminar and hands-on telescope observing, image processing, astrometry, and publishing observations through the IAU Minor Planet Center (MPC)

Course Description

PTYS 516 is focused on developing skills to understand the science and observation of asteroids, comets, and Kuiper Belt Objects (KBOs). Rather than relying primarily on conventional lectures, the course is organized around two professional practices used routinely in planetary astronomy: critical reading of the peer-reviewed literature and the acquisition, reduction, and reporting of optical astrometry that forms the foundational layer of small body science. Each major topic begins with an overview lecture from a guest expert. Subsequent classes are focused on in-class literature review of relevant papers from each of the three topics. The class format would typically be as follows: a peer-reviewed paper is provided at the start of class, students read and annotate it for approximately 45 minutes, and the class spends the remaining approximately 30 minutes analyzing the paper together. Paper identities are generally not announced in advance. Students are graded based on their in-class participation. The observing component of class involves the complete workflow from target selection and observing strategy through image calibration, astrometric measurement, quality control, and preparation of results for the Minor Planet Center submission. The emphasis throughout is on durable scientific skills, judgment, and independence, not on producing a publishable research paper.

Course Prerequisites

Graduate standing in planetary science, astronomy, or a related field, or consent of the instructor. No prior experience with telescope observing or astrometry is assumed. Students should be comfortable with basic astronomical concepts and working with scientific data. Students should be willing to observe at night after class hours.

Course Format and Teaching Methods

- In-person graduate seminar with active, discussion-based learning.
- Overview guest lectures on asteroids, comets, and KBOs.
- Hands-on observing sessions using RAPTORS-II and the 1-meter telescope at the Biosphere 2 Observatory, as scheduled.
- Astrometric data reduction leading to submission and publication of observations by the MPC.
- Final oral presentations integrating literature reading and observational skills. No slides allowed.
- Please Note: Peer-reviewed papers will be distributed at the beginning of class. During the class period, phones, laptops, tablets, internet searches, and generative-AI tools are not used. Students should read,

annotate, identify the central question, evaluate the evidence, and formulate questions for discussion. The goal is to practice distilling scientific meaning directly from the primary literature.

Course Objectives

- Provide a broad, research level view of current questions in asteroid, comet, and KBO science.
- Develop an efficient and repeatable method for reading and critically evaluating journal articles.
- Teach the practical workflow for planning and executing optical observations of small Solar System bodies.
- Develop competence in image calibration, astrometric measurement, uncertainty assessment, and quality control.
- Teach the conventions for preparing and reporting astrometric observations to the MPC.
- Strengthen oral scientific communication through evidence-based discussion and presentation.

Expected Learning Outcomes

By the end of the course, students will be able to:

- Identify and summarize the scientific question, methodology, principal evidence, assumptions, and conclusions of a research paper in asteroid, comet, or KBO science.
- Critique a journal article by distinguishing observation from interpretation and by evaluating limitations, uncertainties, and alternative explanations.
- Compare scientific approaches across the asteroid, comet, and KBO literature and explain how observational constraints shape current understanding.
- Design an observing plan for small bodies using appropriate ephemerides (JPL Horizons or MPC website), cadence, exposure time, target availability, and observing geometry.
- Acquire and work with telescope images of asteroids, comets, and KBOs and apply appropriate calibration and reduction procedures.
- Measure astrometric positions from imaging data, assess the quality of the solution, and recognize common sources of systematic and random error.
- Prepare correctly formatted astrometric observations suitable for submission to the Minor Planet Center and explain the quality control steps required before submission.
- Communicate an observing and analysis workflow clearly in a concise scientific presentation.

Required Texts and Materials

There is no required textbook. Journal articles will be supplied by the instructor in printed form during class and, in general, will not be identified in advance. Required software, observatory access, and data sets needed for the astrometry exercises will be specified during the semester. Students should bring a pencil or pen for annotation to literature sessions. Data reduction and processing will take place during office hours in Prof. Reddy's lab where computers with the necessary software will be provided.

Assessment and Grading

Assessment is intentionally based on demonstrated scientific practice rather than a term paper or conventional exams. The point distribution below follows the activity weights in the course schedule.

Assessment category	Weight	What is assessed
In class participation during literature review, guest lectures, and observatory participation	45%	Active engagement; annotated reading; ability to identify the paper's question, evidence, assumptions, limitations, and implications; thoughtful participation in discussion.

Observing and astrometry exercises	30%	Three topic-based observing projects (10% each). Planning, acquisition or use of provided data, calibration/reduction, astrometric measurement, quality control, and MPC-format reporting.
Final presentation	25%	A concise 15-minute scientific presentation demonstrating an end-to-end observing/astrometry workflow and the scientific reasoning behind the choices made. No slides allowed.

Observing and Astrometry Exercises

The three observing projects are organized around asteroid, comet, and KBO observations. Each practicum is intended to produce high-quality astrometric observations of asteroids, comets, and KBOs rather than a long written report: an observing plan or target selection rationale, reduced images or reduction record, astrometric measurements with quality checks, and a properly prepared MPC-format report. Data collected with each student will be processed during lab/office hours. When the measurements meet the necessary quality standards, observations may be submitted to the Minor Planet Center.

Weather and External Organization Acceptance: Students are not graded on clear weather or on whether an external organization accepts or publishes an observation. If weather or telescope availability prevents data collection, an instructor provided data set may be used. Grades are based on the quality of the planning, analysis, astrometry, quality control, and reporting.

Final Presentation

Final presentations will be held November 23 and 24. The 15-minute presentation should demonstrate scientific judgment rather than simply recount steps. Students should explain the target and observing context, how the data were acquired or selected, the reduction and astrometric workflow, the quality of the resulting measurements, any problems encountered, what they would improve in a future observing run, and how data of this type could expand on the current state of research. Detailed presentation format will be announced in class.

Grading Scale and Policies

Final course grades will be assigned using the following scale unless the instructor announces a different scale in writing before graded work begins: A = 90-100%, B = 80-90%, C = 70-80%, D = 60-70%, E = below 60%. Grades are based on demonstrated engagement and skill; successful scientific work includes recognizing uncertainty, diagnosing problems, and documenting unsuccessful approaches.

Attendance and Participation

Attendance is especially important because most literature activities occur entirely in class and cannot be recreated by watching a recording or reading posted notes. Students who must miss class for a university-recognized or otherwise approved reason should contact the instructor as early as possible. The instructor will determine an appropriate make-up activity when one is necessary. Observing sessions are weather dependent and may require reasonable schedule adjustments.

Generative AI and Digital-Tool Policy

The central purpose of this course is to develop the ability to read primary literature, reason from evidence, plan observations, and perform astrometric analysis independently. For that reason, generative artificial-intelligence / large-language-model tools (for example, ChatGPT, Gemini, Claude, Copilot, Perplexity, or similar systems) may not be used for graded course work unless the instructor explicitly authorizes their use for a particular activity.

- Do not use AI to summarize, explain, contextualize, critique, or answer questions about the in-class journal papers.
- Do not photograph, scan, transcribe, or enter any part of an in-class paper or assignment into a generative-AI system.
- Do not use AI-generated text, analysis, code, tables, figures, or citations in graded work unless specifically authorized.
- Standard scientific software, ephemeris services, image-processing packages, astrometric tools, and ordinary non-generative computational tools are permitted when appropriate.

This policy is not a judgment that generative AI is never useful in scientific work. It is a course design choice: using AI for the core reading and analysis tasks would bypass the skills this course is intended to build. If an assignment later permits AI, the instructor will specify the allowed uses and any acknowledgment requirements. When in doubt, ask before using the tool.

Academic Integrity

Students are expected to follow the University of Arizona Code of Academic Integrity. Work submitted for assessment must reflect the student's own scientific reasoning and must comply with the course policy on generative AI and collaboration. Collaboration during telescope operations and discussion is expected where directed; individual assessed products must represent the student's own work unless the instructor explicitly identifies a group product.

Schedule of Topics and Activities

The schedule below follows the current course plan. Literature-paper titles are intentionally omitted and will normally be revealed only when the paper is distributed in class. Observing activities may shift because of weather, telescope availability, or target visibility.

Date	Topic / Activity	Format / Notes	Grade weight
Mon Aug 24	Syllabus Review / Introduction to Asteroids	Guest overview: Dr. Adam Battle	2.5%
Tue Aug 25	Asteroids: Paper 1	Analog paper reading + discussion	2.5%
Mon Aug 31	Asteroids: Paper 2	Analog paper reading + discussion	2.5%
Tue Sep 1	Asteroids: Paper 3	Analog paper reading + discussion	2.5%
Mon Sep 7	Labor Day	No class	-
Tue Sep 8	Asteroids: Paper 4	Analog paper reading + discussion	2.5%
Mon Sep 14	Visit to Biosphere 2, Intro to Telescopes	Observing / Asteroid astrometry	5%
Tue Sep 15	Observing Asteroids with RAPTORS-II	Observing / Asteroid astrometry	5%
Mon Sep 21	Introduction to Comets	Guest overview: Prof. Walt Harris	2.5%
Tue Sep 22	Comets: Paper 1	Analog paper reading + discussion	2.5%
Mon Sep 28	Comets: Paper 2	Analog paper reading + discussion	2.5%
Tue Sep 29	Comets: Paper 3	Analog paper reading + discussion	2.5%

Mon Oct 5	Comets: Paper 4	Analog paper reading + discussion	2.5%
Tue Oct 6	Comets: Paper 5	Analog paper reading + discussion	2.5%
Mon Oct 12	Observing Comets	Observing / Comet astrometry	5%
Tue Oct 13	Observing Comets	Observing / Comet astrometry	5%
Mon Oct 19	Introduction to KBOs	Guest overview: Dr. Kat Volk	2.5%
Mon Oct 26	KBOs: Paper 1	Analog paper reading + discussion	2.5%
Tue Oct 27	KBOs: Paper 2	Analog paper reading + discussion	2.5%
Mon Nov 2	KBOs: Paper 3	Analog paper reading + discussion	2.5%
Tue Nov 3	KBOs: Paper 4	Analog paper reading + discussion	2.5%
Mon Nov 9	KBOs: Paper 5	Analog paper reading + discussion	2.5%
Tue Nov 10	Observing KBOs	Observing / KBO astrometry	5%
Mon Nov 16	Observing KBOs	Observing / KBO astrometry	5%
Tue Nov 17	Review and Q&A	Preparation for presentations	2.5%
Mon Nov 23	Final Presentations	Student presentations	25%
Tue Nov 24	Final Presentations	Student presentations	-

Safety on Campus and in the Classroom

For emergency procedures and campus safety information, consult the University of Arizona Critical Incident Response Team (CIRT): https://cirt.arizona.edu/case-emergency/overview. Students participating in evening or observatory activities must follow all facility, telescope, transportation, weather, and instructor safety requirements.

Nondiscrimination and Anti-harassment Policy

The University of Arizona is committed to creating and maintaining an environment free of discrimination, harassment, and retaliation. For the University's nondiscrimination and anti-harassment policy and reporting information, see: http://policy.arizona.edu/human-resources/nondiscrimination-and-anti-harassment-policy

University Policies

University policies that apply to course syllabi, including accessibility, attendance, threatening behavior, and academic integrity, are available at: https://catalog.arizona.edu/syllabus-policies

Graduate Student Resources

Graduate students who need support with food, housing, finances, health, or other basic needs can find University of Arizona resources at: http://basicneeds.arizona.edu/index.html

Subject to Change Notice

Information contained in this syllabus, other than grade and absence policies, may be subject to change with reasonable advance notice, as deemed appropriate by the instructor. Weather, telescope access, and target visibility may require changes to observing dates.