

PLANETS IN THE UNIVERSE (AST 205)

Fall 2019 — V01¹

BASIC INFORMATION

This is an introductory course in astronomy focusing on planets in our Solar System, and around other stars (exoplanets). The course starts with reviewing the formation, evolution and characterization of the Solar system, including the Sun. Following an introduction to stars, the course will then discuss the exciting new field of exoplanets; discovery methods, basic properties, earth-like planets, and extraterrestrial life. Core values of the course are quantitative analysis and hands-on experience, including telescopic observations and astrophotography. This STN course is designed for the non-science major and has no prerequisites past high school algebra and geometry. More information on the course can be found at <http://www.astro.princeton.edu/~gbakos/AST205/>, and on blackboard.

Lectures: Peyton Lecture Hall ($\lambda = 74^{\circ}39'06.0''\text{W}$, $\varphi = 40^{\circ}20'47.8''\text{N}$) Tue, Thu 1:30–2:50pm

INSTRUCTORS

Professor:

Gáspár Áron Bakos (133 Peyton Hall, x8-9926, gbakos@astro.princeton.edu)

Office hours: Tue, Thu 3:00–4:00pm

Teaching assistants:

Sam Yee (Tue 17:00–19:00, xxx Peyton Hall, syee@princeton.edu)

Miles Cranmer (Tue 19:00–21:00, xxx Peyton Hall, miles.cranmer@gmail.com)

Amy Secunda (Fri 13:00–15:00, xxxx Peyton Hall, asecunda@princeton.edu) **Observing assistants:**

Lauren Von Berg (evenings, lmberg@princeton.edu)

Emma Loudon (evenings, eloudon@princeton.edu)

Don Geci (evenings, dgeci@princeton.edu)

READING LIST²

Required

- **The Cosmic Perspective (Bennett, Donahue), 8th edition**, ISBN-10: 0134059069

We will cover parts III, V, VII, and selected subjects from parts I, II. Register at www.masteringastronomy.com.

Highly suggested

- *How to Find a Habitable Planet* (Kasting, 2012), 9780691156279.
Entertaining and moderately light read.
- *How I Killed Pluto and Why It Had It Coming* (Brown, 2010), 0385531087.
Suggested, entertaining and light read.
- *5 Billion Years of Solitude: The Search for Life Among the Stars* (Billings, 2014), 1617230162
Highly relevant to the course.

Recommended

- *The Exoplanet Handbook* (Perryman), 0521765595,
Advanced reference material, primarily for graduate students. Electronic version available for

¹Typeset October 12, 2019

²All of these books have reserve copies in the library: <http://princeton.beta.libguides.com/astro/reserves>

Princeton students.

<http://site.ebrary.com/lib/Princeton/docDetail.action?docID=1047648>

- *Mirror Earth* (Lemonick, 2013), 9781620403105. Excellent book by one of our visiting lecturer.

If you want to kill time

- *Red Mars (Mars Trilogy)* (Robinson, 1993), .
Good and detailed sci-fi (very long).
- *Extrasolar Planets and Astrobiology* (Scharf, 2008), 1891389556.
Mildly suggested. Strong in astrobiology, moderately advanced.
- *Exoplanets* (Seager), 0816529450,
Mildly suggested, advanced. Certain chapters available on-line.
- *Strange New Worlds: The Search for Alien Planets and Life beyond Our Solar System* (Jayawardhana, 2011), 0691142548.

REQUIREMENTS AND GRADING

- Mid-term exam: 15%
- Final exam: 25%
- Homework assignments: 30% (5 assignments, every second week, each worth 7.5%, and the worst one is dropped.)
- Group activities including telescopic observations (12%) and digital photography (12%)
- Participation in discussion forums: 6%
- Reading load: about or less than 42 pages per week, primarily from the textbooks, and to lesser extent from on-line media (news).

Students are expected to participate in group activities that involve telescopic observations and photography using a variety of astronomical equipment that will be loaned out to the students and groups. Lectures will also include daytime observations during the lectures. No solar observations permitted without the presence of the Professor or the TAs. Without participation (even if at a *minimal level*) in all three of the group activities, i.e. visual observing, photography, and reading journals, one can not pass the course. Participation on at least one star party is also compulsory (and should be fun anyway). Joining multiple star parties is optional, but will certainly help in grasping observational astronomy. *Please*, no laptops, ipads, and similar form of entertainment during the lectures.

SCHEDULE

We will discuss topics in the following approximate order: our Solar System (planets, comets, asteroids, general properties), our own Sun, other stars, planets around other stars (exoplanets), and extraterrestrial life. Each lecture will start with 5–10 minutes of astronomy and planet related news. Almost all of these news will be suggested by student groups. Basic concepts in physics and astronomy will be discussed in context, as we proceed with our main subject.

Please note, the following, detailed schedule is subject to minor changes, depending on how fast we progress and how many daytime observations we cover in our class. “News” items will be added to the syllabus as we progress.

Date	Instructor	Topics
01:Sep 12	Bakos	Introduction, logistics. Our place and motion in the Universe. Quick tour of the Solar System (SS). (Cosmic Perspectives [hereafter CP] Ch. 7). Basic concepts (BC): mass, volume, density, scaling relations.
02:Sep 17	Bakos	News: Andromeda crashing in our Galaxy. Introduction to the Solar System continued, Venus through comets (CP Ch7). Observing: a star in the daytime sky. Also read: CP Ch1 (light read).
03:Sep 19	Bakos	News: 'Oumuamua, the first interstellar asteroid. BC: motion, inertia, force, momentum, Newton's laws, moment of inertia, angular momentum, conservation laws (CP Ch. 4.1, 4.2, 4.3).
04:Sep 24	Bakos	News: The first interstellar comet. BC: energy and temperature (CP 4.3). Light and matter, part I: rainbows, spectroscopy, waves, electromagnetic field, properties of light (CP 5).
05:Sep 26	Bakos	News: Planet K2-18b in the habitable zone. Light and matter, part II: Structure of matter. Spectroscopy, IR radiation, blackbody radiation, SB and Wien's law (CP.5). Also read: CP.2 (light read, important for observations & star parties). HW1 announced.
06:Oct 01	Bakos	News: Search for Planet IX. Light and radiation continued.
07:Oct 03	Bakos	News: Three merging supermassive black holes. The Sun: basic properties, structure, activity, equilibrium, oscillations, neutrinos. Sun-Earth connection, aurorae (CP.14). BC: nuclear fusion. BC: radiometric dating (CP.8.3). BC: virial theorem.
08:Oct 08	Bakos	News: A hot jupiter orbiting a red dwarf star. BC:refraction. Telescopes and detectors: types, principles, history, ground-based, space-born (CP.6).
09:Oct 10	Bakos	News: galaxies switching on to quasars. Models of the SS (geocentric, heliocentric, epicycles). Historical overview. Copernican revolution, Kepler's laws, Galilei's observations (CP.3). Please also read: CP.S1. HW1 due before lecture. HW2 out.
10:Oct 15	Bakos	News: TBD. Formation of the SS. Protostellar nebulae. Collapse of a cloud. Formation of stars and planets. Snow-line, accretion, migration (CP.8). Formation of the Solar System continued (rocky, gaseous planets, small SS bodies).
11:Oct 17	Bakos	News: TBD. Terrestrial planets, planetary interiors, seismology, differentiation. Magnetic fields. Cratering, volcanism, plate tectonics, erosion. (CP9) Geology of terrestrial planets, including the Earth (CP9). ST: Water on Earth.
12:Oct 22	Bakos	Planetary atmospheres of terrestrial worlds (CP.10). BC: pressure. Equilibrium temperature, green-house effect. Earth's atmospheric structure. Weather and climate. BC: General law of gravity (please read CP.4.4). HW2 due before lecture.

13:Oct 24	Bakos	Mid-term exam (location: in class).
FALL RECESS		
14:Nov 05	Bakos	News: TBD. Jovian planetary systems, compositions, atmospheres. Atmospheres of Jovian planets (J,S,U,N). Discovery of Uranus and Neptune. Satellites of Jovian planets. (CP.11). HW3 announced.
15:Nov 07	Bakos	News: TBD. Continue with Satellites of Jovian planets. Rings of jovian planets, dwarf planets, Pluto, Kuiper belt. Impacts, and the outer Solar system (CP.12). We are leaving the Solar System. . . Highly recommended reading: "Brown:How I killed Pluto. . ."
16:Nov 12	Bakos	News: TBD. Asteroids, occultations, meteors, comets. (CP.12). Dwarf planets.
17:Nov 14	Bakos	News: TBD. Stars: basic properties, relations between stellar parameters. Parallax. Stellar spectra. Binaries. Stellar evolution. Variable stars. Star clusters. (CP.15). HW3 due before lecture. HW4 announced.
18:Nov 19	Bakos	News: TBD. Introduction to exoplanets. (CP.13). Overview of detection methods. Dynamical methods, planets around pulsars, white dwarfs, eclipsing binaries (CP.17).
19:Nov 21	Bakos	News: TBD. ST: Doppler effect. Detecting exoplanets via the line-of-sight velocity of the host stars (Doppler shifts, granulation). Spectrographs, limits on precision, famous discoveries. Statistical parameters of planets based on the RV method. (CP.13 finish, also read CP.18).
20:Nov 26	Bakos	News: TBD. Famous RV discoveries. Statistical parameters of planets based on the RV method. (CP.13 finish, also read CP.18). Gravitational lensing. HW4 due.
THANKSGIVING RECESS		
21:Dec 03	Bakos	News: TBD. Direct imaging of exoplanets. Gravitational lensing. Covering missing basic concepts. HW5 out.
22:Dec 05	Bakos	News: TBD. Transiting planets, Geometry and parameters of the transits. Transit surveys. Q&A session.
23:Dec 10	Bakos	News: TBD. Transiting planets continued: limb darkening, spot crossing, spin-axis alignment, occultations. Transmission spectroscopy. Exomoons and life. The transits of Venus (historical overview).
24:Dec 12	Bakos	News: TBD. Exomoons, life in the universe. The transits of Venus (historical overview). HW5 due.
Jan xx-xx Jan xx Jan xx-xx Jan xx	TAs	Review sessions. HW5 due Jan 9 12:00 EST. Group journals closed at midnight EST. FINAL EXAMS PERIOD Final exam, time TODO, location TODO