ASTRONOMY 100Lg: THE UNIVERSE

Fall 2015 [class # **50800**] **Syllabus** Dr. Däppen

Classes meet:	TTh 12-1:50pm, SLH 200
	(**Exams may be in different rooms - to be announced!**)
Office/Contact:	SHS 370, 740-1316, e-mail: `dappen@usc.edu`
Office hours:	Monday 11am-12noon (SHS 370) &
	TTh 1:50-3pm (classroom and/or SHS 370),
	and by appointment (arranged in person, by phone, or e-mail)
Labs meet:	SGM 313 **(consult p. 7 for your lab days!)**
Lab director:	Joseph Vandiver, SGM 309 , 740-8889;
	e-mail: `vandiver@usc.edu`
Lab-TA Office:	SGM 300 & 311 & 313 (hours TBA)
Departmental-TA Office:	ACB 431 (hours TBA)

Course description (Catalogue):

Survey of the universe: planets, satellites, comets, stars, nebulae, galaxies. Practical component includes planetary observations and dark-sky field trip.

Expanded Course description:

The marvelous ballet of the starry sky has fascinated mankind since prehistoric times. The questions, for instance, "Where are we?" and "What is the universe?" have spurred the development of astronomy. It will be shown how the quest for the nature of the universe has tremendously helped the development of physics. And physics, in turn, has paid back generously, by delivering the very concepts that allow us to understand the seemingly weirdest things in the universe. This course is designed for non-science majors with very little, if any, background in the sciences and mathematics. The course is non-mathematical by prerequisite, but you will encounter some calculations. However, they will be very simple and employ formulae that are easy to remember. You will have the opportunity to realize that formulae represent ideas because mathematics is the language of science. As with any language, there are different levels of ambition. One can study thoroughly for many years, or merely buy a phrase book to be opened in the airplane before arriving. You may have experienced how ten well chosen expressions can make all the difference. Something similar could happen to your relationship with astronomy!

The point was driven home by someone who said it more beautifully than I could myself: *In a large public lecture, the famous British astrophysicist Hermann Bondi mentioned the following hypothetical proposal. Imagine going in the street and asking around if somebody would be willing to learn Chinese within two years for the good pay of 250,000 pound sterling. He conjectured that there would be some respondents willing to try. After all, he would only ask for a level of fluency to understand what other people produced, that is, to be able to read, not write, literature. After that, Hermann Bondi asked to imagine the same inquiry regarding the willingness of people to learn theoretical physics. Just in order to understand the concepts other people have discovered, not to discover new physics. Alas, Hermann Bondi feared that despite the promised cash reward the response would be a universal "No, this is above my abilities".* And this from the same people who could imagine learning Chinese. How wrong! How sad!

Learning objectives:

On completion of the course, students should be able to:

- understand how science is done, what questions science can answer, and what questions science cannot answer;
- gain an appreciation for the historical development of astronomy, including the importance of past discoveries in the development of new knowledge;
- appreciate the role of physics in astronomy;
- acquire a better appreciation for the wonders of the universe;
- cultivate an interest in learning more about astronomy throughout their lives, such that they will want to read articles about astronomy in the future after this class has ended.

Tentative Schedule:

THE DETAILED WEEKLY READING ASSIGNMENTS ARE ON PAGES 7-11

Week	Date	Topic	Source
1	8/25-27	Introduction; Science; Celestial Motion	book+**notes**
2	9/ 1 - 3	Earth; Moon; Greek Astronomy	book+**notes**
3	9/ 8 -10	The Astronomical Revolution	book+**notes**
		Deadline: Dropping without W, Electing P/NP: September 11	
4	9/15-17	Radiation, Photons & Atoms	book+**notes**
		FIRST MIDTERM EXAM: **Tuesday, Sep. 22** (Bring No. 2 pencil)	
5	9/22-24	Spectroscopy; Telescopes	book
6	9/29-10/1	Non-optical Astronomy; Solar System I (General)	book
7	10/ 6 - 8	Solar System II (Planets, Moons & Small Things)	book+**handout**
		Deadline: Change P/NP to letter grade: October 9	
8	10/13-15	Solar System II (cont'd); Extra-solar Planets	book
		SECOND MIDTERM EXAM: **Tuesday, Oct. 20** (Bring No. 2 pencil)	
9	10/20-22	Stellar Quantities; HR Diagram; Binaries	book
10	10/27-29	Stellar Evolution I (Including the Sun – Our Star)	book+**handout**
11	11/ 3 - 5	Stellar Evolution II	book+**handout**
12	11/10-12	Our Galaxy (*only to be tested on the final exam!)*	book
		Deadline: Dropping with W: November 13	
		THIRD MIDTERM EXAM: **Tuesday, Nov. 17** (Bring No. 2 pencil)	
13	11/17-19	Other Galaxies; Truly Cosmic Distances	book
14	11/24	Other Galaxies; Active Galaxies, Quasars; Dark Matter	book+**handout**
		Thanksgiving Day: November 26	
15	12/ 1 - 3	Cosmology; Dark Energy; Early Universe; Topics; Final Review	book

ALL STUDENTS (NO EXCEPTIONS) MUST TAKE THE
FINAL EXAM, **Tuesday, December 15, 11 a.m.-1 p.m.**

Text: Chaisson & McMillan - *Astronomy Today (Eighth Edition)*

Exams

Note that for all exams, the **room (or rooms!)** may differ from the usual class room. The location of the exam room(s) will be announced later.

There will be three mid-term examinations (during the usual class times) and one scheduled final exam. Of the three mid-terms, only the scores of the two highest will be counted. More precisely, I will completely drop the score of the one midterm that would pull downward the overall course grade most strongly. Thus, the overall course grade will be based upon the examinations as follows: the **two** best mid-term exams are **each** worth 20% of the total score of the course, the final exam is worth 25% the total score of the course. [The remaining 35% of the total score are for the laboratory (20%) and homework (15%); see below]. **All exams are closed book.**

Grading: Broadly speaking, grading is by the **distribution curve** of the combined scores of exams, homeworks and lab. Please note that I do **not** use rigid percentage marks (such as, *e.g.*, a rule that 90% would correspond to an A- or similar). Further details about the grading procedure are **given in class**.

As a consequence of the grading policy, the third mid-term exam can serve as a make-up exam for either of the first two exams (no questions asked!). However, there will **not** be any other make-up exams. Any student missing two of the three mid-terms, will only have recorded the points scored on the one exam taken.

In the week before each exam I will **review the essential topics** and indicate which material could be on the test.

The final exam will be held on **Tuesday, December 15, 11 a.m.-1 p.m**. There can be no change in the final exam date for anyone.

Homework

There will be four homework sets according to the following

Homework Schedule

Homework # 1	given out:	Sep. 8	**DUE:**	**Sep. 17**
Homework # 2	given out:	Sep. 29	**DUE:**	**Oct. 8**
Homework # 3	given out:	Nov. 3	**DUE:**	**Nov. 12**
Homework # 4	given out:	Nov. 24	**DUE:**	**Dec. 3**

For those who miss the distribution in class, the assignments can also be found posted on **Blackboard** (see below, p. 4).

The homework problems are intended to provide useful (but, by no means, comprehensive) preparation for the exams. Note, however, that the exams will have multiple choice questions, while the homework will involve longer problems with more complicated answers. (Exams will be graded by machines, homework by humans.) Since the students in this class have different educational backgrounds, I will give some choice between more quantitative and more qualitative problems.

For those homework due dates that are too close to a following exam, it can be logistically impossible to return the graded homework in time for the exams. However, I will always post the solutions immediately after the due day (on **Blackboard**, see below, p. 4). Therefore, if you wish to compare your own answers with the posted solutions before the graded homework is back, you would have to rely on your memory or make copies of your homework submissions.

Homework will count for 15% in the overall score. Each of the four homework scores is given equal weight, and each set with a perfect score gives 5%. However, my policy is to cap the total homework score at 15%. You can therefore obtain the maximum homework score of 15% already with three out of the four assignments. Or, since homework scores "roll over" - unlike those of exams -, you have the possibility to achieve a flawless homework total score by turning in all 4 assignments despite deficiencies in individual scores. In particular, this policy allows you to get a perfect homework score even by solving only the non-quantitative problems in the 4 assignments!

You are encouraged to work together on the problem sets (in fact, the absolutely best way to make sure you understand how to answer a question is to see if you can explain it to someone else), but the final write-up must be your own. Please follow the Golden Rule: explain your answers as you would like them to be explained to you; the graders will be looking at completeness, clarity, and legibility, not just the final answer. There is no need to be verbose: the answers can be crisp and clear. Please check your course score on the web site every once in a while.

My email

The best way **to contact me** is via e-mail (`dappen@usc.edu`).

Blackboard

Blackboard is the USC web-based interface between classes, students and instructors. Access is through `http://blackboard.usc.edu`, using your USC login name and password.

i) Old Exams,

ii) Homework Assignments and Homework Solutions,

iii) Handouts, and

iv) Information on your test and homework scores.

Regarding the last item, finding your test and homework scores can help you to double check your own records against mine. For instance, sometimes (hopefully very rarely) a student's homework might be mislaid. The information given by blackboard allows you to detect such problems in time. So please check it regularly. If you obtain what you believe is incorrect information, please discuss the matter with me immediately.

Astronomy in the Internet

Finally, to get some gorgeous photographs and rather useful stuff, you might try, for instance, some of the following **astronomy-related web sites** (and further links contained therein). The last of the list is a link to Phil Plait's "Bad Astronomy" website, which I can recommend as an entry point into popular controversies between science and pseudo-science.

http://www.jpl.nasa.gov/
http://hubblesite.org/newscenter/
http://hubblesite.org/gallery/
http://seds.org/
http://skyandtelescope.com/
http://apod.nasa.gov/apod/
http://www.badastronomy.com/index.html
+ many more (use, e.g., Google)

The four following links lead to similar material, but in addition also to a wealth of information about current, past and future **spaceflights** (manned and unmanned).

http://www.spaceflightnow.com/
http://www.planet4589.org/space/
http://www.astronautix.com/
http://carlkop.home.xs4all.nl/astroeng.html
http://www.nasawatch.com/index.html
http://www.cnn.com/TECH/

USC-mandated communications

(i) Accommodation for students with disabilities

Any student requesting academic accommodations based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP. Please be sure the letter is delivered to me (or to TA) as early in the semester as possible. DSP is located in STU 301 and is open 8:30 a.m.-5:00 p.m., Monday through Friday. The phone number for DSP is (213) 740-0776.

(ii) Academic Integrity

USC seeks to maintain an optimal learning environment. General principles of academic honesty include the concept of respect for the intellectual property of others, the expectation that individual work will be submitted unless otherwise allowed by an instructor, and the obligations both to protect one's own academic work from misuse by others as well as to avoid using another's work as one's own. All students are expected to understand and abide by these principles. Scampus, the Student Guidebook, contains the Student Conduct Code in Section 11.00, while the recommended sanctions are located in Appendix A: http://www.usc.edu/dept/publications/SCAMPUS/gov/. Students will be referred to the Office of Student Judicial Affairs and Community Standards for further review, should there be any suspicion of academic dishonesty. The Review process can be found at: http://www.usc.edu/student-affairs/SJACS/.

(iii) Sexual harassment

Sexual harassment is a serious matter. Please see the information at the Sexual Assault Resource Center for the University of Southern California at https://sarc.usc.edu/reporting-options/ for guidance in dealing with these kind of issues. Contact phone numbers are: business hours: (213) 740-4900; after hours, call the on-call counselor at (213) 321-3982. You may also opt to contact the USC Center for Work and Family Life (213) 821-0800, http://www.usc.edu/programs/cwfl/). Both resources are confidential.

LABORATORY

The course Physics 100 has a mandatory laboratory component, and you should already be signed up for one of the laboratory sessions. The purpose of the laboratory is to give you some feeling for making and interpreting experiments, thereby reinforcing some of the course material.

I hope that our laboratory will enhance your experience and enjoyment of this course. Please appreciate the great logistical complexity of arranging laboratories for so many people with such a broad variety of backgrounds: I therefore kindly request your good will and patience in this enterprise.

FIRST THINGS FIRST: The First Laboratory Meeting

For our class (labs # 50802-50809), your first meeting will be held in the week of Aug. 31 - Sep. 4, ON YOUR SPECIFIC LABORATORY DAY. It is very important to attend the first session.

For your convenience, on the following page, I include the tentative basic laboratory schedule (courtesy of the laboratory director). Further details will be given during your first laboratory meeting.

Please note that the **organization** of the laboratory is completely independent of the class. Therefore, your laboratory grade (which, as mentioned before, constitutes 20% of your overall score) will be derived **solely from your performance in the laboratory, and in accordance with the rules established by the laboratory.**

Astronomy 100

Location SGM-313

Week of Semester	Dr. Peroomian's Section	Dr. Dappen's Sections
August 24th	Basic Aspects	No Lab
August 31st	No Lab	Basic Aspects
September 7th	The Sun	No Lab
September 14th	No Lab	The Sun
September 21st	Optics	No Lab
September 28th	No Lab	Optics
October 5th	Daytime Observations	No Lab
October 12th	No Lab	Daytime Observations
October 19th	Kepler's Laws	No Lab
October 26th	No Lab	Kepler's Laws
November 2nd	Distance to M4	No Lab
November 9th	No Lab	Distance to M4
November 16th	Digital Astronomical Photography	No Lab
November 23rd	Thanksgiving Week	Thanksgiving Week
November 30th	No Lab	Digital Astronomical Photography

DETAILED SYLLABUS:
WEEKLY READING ASSIGNMENTS

Re: "make notes": some material presented in the lectures may differ significantly from the textbook. I have indicated where this is going to happen by the flags "**make notes**" and "**hand-out**". As a rule, if you see **make notes** in the syllabus, you should really ... **make notes**. That material can be on the tests!
Making notes is also recommended for the **"the planet weeks" (7+8)**! However, in that case the notes will be good for the opposite reason. We will **restrict** ourselves to a manageable mandatory part, and in class, you will hear how to deal with the otherwise inhuman reading assignments of those two weeks!

Note: In the following list, "MP" refers to the "More Precisely" sections, "DI" to the "Discovery" sections of the textbook.

Week 1: Introduction; Science; Celestial Motion

(a) Why astronomy (**just listen!**)

(b) Science, non-science, scientific method [Section 1.2 (pp. 8-9)]

(c) Constellations, celestial sphere [Section 1.3 (pp. 10-13top); **MP** 1-1 (p. 14)]

(d) Celestial coordinates (**make notes**)

(e) Changes: day-to-day; seasonal; long-term; calendar [Section 1.4 (pp. 13-17)]

Week 2: Earth; Moon; Greek Astronomy

(a) Moon, eclipses [Section 1.5 (pp. 18-23)]

(b) Size of Earth; Distance measurements (parallax)
[Section 1.6 (pp. 24-27); **MP** 1-2 (p. 28)]

(c) A selection of outstanding Greek astronomers
[Aristotle (p. 9); Eratosthenes (p. 27); Aristarchus (pp. 39);
Hipparchus (p. 426); Ptolemy (p. 38-39) + **make notes**]

(d) Motion of the planets: geocentric model [Section 2.2 (pp. 36-39)]

Week 3: The Astronomical Revolution

(a) Motion of the planets: heliocentric model, Copernicus [Section 2.3 (pp. 39-41)]

(b) Galileo and the telescope [Section 2.4 (pp. 41-43)]

(c) Tycho Brahe's observations, Kepler's laws [Section 2.5 (pp. 44-47)]

(d) Size of the solar system [Section 2.6 (pp. 47-49)]

(e) The completion of the astronomical revolution: Newtonian Physics or
"From crystal spheres to rocks flying in space"
[Section 2.7 (pp. 49-55) + **make notes**]

Week 4: Radiation, Photons & Atoms

(a) Waves in general and electromagnetic waves in particular
[Sections 3.1,3.2,3.3 (pp.60-68)]

(b) The speed of light: a stupendous **astronomical** discovery (**make notes**)

(c) Temperature and radiation: black bodies
[Section 3.4 (pp. 68-73); **MP** 3-1 (p. 69); **MP** 3-2 (p. 72)]

(d) Moving sources: Doppler effect [Section 3.5 (p. 73-74); **MP** 3-3 (p. 75)]

(e) Spectral lines [Section 4.1 (pp. 80-83)]

(f) Atomic structure [Section 4.2, before "Radiation as Particles" (pp. 84-85)]

(g) Photons [Section 4.2, from "Radiation as Paricles" onward (pp. 85-87); **DI** 4-1 (p. 88)]

(h) A crash course in modern physics (**make notes**)

Week 5: Spectroscopy; Telescopes

(a) Spectrum of hydrogen (**MP** 4-1 (p. 86))

(b) Formation of Spectral Lines; Kirchhoff's laws [Section 4.3 (pp. 87-90)]

(c) Spectroscopy as a fundamental astronomical tool; Line broadening: Doppler effect revisited) [Section 4.5 (pp. 92-95)]

(d) Telescopes [Section 5.1 (pp. 100-104) and the **appropriate laboratory session**]

(e) Need for large telescopes [Section 5.2 (pp. 105-108)]

(f) Modern telescope design [Section 5.4 (pp. 111-114)]

Week 6: Non-optical Astronomy; Solar System I (General)

(a) Radio astronomy [Section 5.5 (pp. 114-118)]

(b) Further non-optical astronomy [Section 5.7 (pp. 121-128)]

(c) Full spectrum coverage [Section 5.8 (p. 128)]

(d) Overview of the solar system [Sections 6.1,6.2,6.3 (pp. 136-140); Table 6-1 (p. l38)]

(e) Properties and classification of planets [Section 6.4 (pp. 140-143)]

(f) What is holding the atmosphere of a planet? [**MP** 8-1 (pp. 196-197)]

(g) A theory of the origin of the solar system
[Section 6.6 (pp. 144-152); **MP** 6-1 (p. 149); Sections 15.1,15.2 (pp. 368-370)]

Week 7: Solar System II (Planets, Moons & Small things)

(a) Earth: overall [Section 7.1 (p. 162)]

(b) Earth: atmosphere [Section 7.2 (pp. 162-168)]

(c) More on the greenhouse effect [**DI** 7-1 (p. 167)]

(d) Earth: interior [Section 7.3 (pp. 168-172)]

(e) Earth: plate tectonics [Section 7.4 (pp. 173-179)]

(f) Earth: tides [Section 7.6 (pp. 182-184)]

(g) **How to learn the following 7 chapters (8-14) economically?**
(see **handout** and **make notes**)

(h) Moon; Mercury [Chapter 8]

Week 8: Solar System II (Planets, Moons & Small things - continued; Extra-solar planets)

(a) Venus [Chapter 9]

(b) Mars [Chapter 10]

(c) Jupiter [Chapter 11]

(d) Saturn [Chapter 12]

(e) Uranus, Neptune [Chapter 13]

(f) Our beloved Pluto [Section 14.3 (pp. 353-356)]

(g) Other small things: asteroids, comets [Sections 14.1,14.2 (pp. 340-348); meteoroids 14.4 (pp. 358-362) – **all this still with "economical" reading!**]

(h) Extra-solar planets; Open issues (How unusual is the Solar System?) [Sections 15.3 (pp.370-373);15.4,15.5 (pp. 373-382)]

Week 9: Stellar Quantities; HR Diagram; Binaries

(a) Stellar parallax, Distances; Motion [Section 17.1 (pp. 422-425)]

(b) Stellar luminosity and apparent brightness
[Section 17.2 (pp. 425-427); **MP** 17-1 (p. 430)]

(c) Stellar temperature, color & spectral type[Section 17.3 (pp. 428-431)]

(d) Stellar sizes [Section 17.4 (pp. 432-434); **MP** 17-2 (p. 433)]

(e) Stellar classification: Hertzsprung-Russell (HR) diagram [Section 17.5 (pp. 434-436)]

(f) Cosmic distance scale I: spectroscopic parallax [Section 17.6 (pp. 437-439)]

(g) Binary stars and stellar masses; classification of binaries [Section 17.7 (pp. 440-442); **MP** 17-3 (p. 443)]

(h) Relation between mass, luminosity and radius [Section 17.8 (pp. 442-444)]

Week 10: Stellar Evolution I (Including the Sun – Our Star)

(a) Overall considerations [Section 19.1 (pp. 470-472); **handout**]

(b) A star like the Sun: birth and nuclear fusion [Section 19.2 (pp. 472-477); Section 16.6 (pp. 410-414); **MP** 16-2 (p. 416)]

(c) Crucial role of mass: ZAMS [Section 19.3 (pp. 477-478)]

(d) Star clusters [Section 19.6 (pp. 486-491)]

(e) A star like the Sun: high age [Sections 20.1,20.2 (pp. 496-502); **handout**]

(f) Overall properties of the Sun [Section 16.1 (pp. 390-392); **MP** 2-2 (p. 54)]

(g) Solar interior - a theorist's paradise [Section 16.2 (pp. 392-397)]

(h) The "neutrino Sun" 16.7 (pp. 414-415); (**make notes**)

(i) Solar atmosphere [Section 16.3 (pp. 397-400)]

(j) Solar activity and cycle [Section 16.4 (pp. 400-409)

Week 11: Stellar Evolution II

(a) Evolution of high-mass stars [Section 20.4 (pp. 509-512); **handout**]

(b) Star clusters as tests of the theory of stellar evolution [Section 20.5 (pp. 512-515)]

(c) End phases I: white dwarfs, planetary nebulae & novae
[Sections 20.3 (pp. 502-509); 21.1 (pp. 522-523); **handout**]

(d) End phases II: neutron stars, pulsars [Sections 22.1,22.2,22.3 (pp. 544-552)]

(e) End phases III: black holes [Sections 22.5,22.6 (pp. 555-561); **DI** 22-1 (pp. 559)]

(f) End phases IV: Core collapse of high-mass stars; Supernovae [Sections 21.2,21.3 (pp. 524-530); **handout**]

(g) Creation of chemical elements [Section 21.4 (pp. 530-538); **handout**]

(h) The role of stellar evolution in the universe [Section 21.5 (pp. 538-539); **handout**]

Week 12: Our Galaxy

(a) The Milky Way Galaxy [Section 23.1 (pp. 578-579)]

(b) Cosmic distance scale II: variable stars [Section 23.2 (pp. 579-586)]

(c) Structure of our Galaxy: halo and disk [Section 23.3 (pp. 586-589)]

(d) Spiral structure [Section 23.5 (pp. 591-595); **DI** 23-2 (p. 594)]

(e) Mass of our Galaxy [Section 23.6 (pp. 595-599)]

(f) The center of our Galaxy [Section 23.7 (pp. 599-602)]

Week 13: Other galaxies; Truly Cosmic Distances

(a) Galaxies by type [Section 24.1 (pp. 608-614)]

(b) Cosmic distance scale III: beyond variable stars [Section 24.2, before "Clusters of galaxies" (pp. 615-616)]

(c) Clusters of galaxies [Section 24.2, part on "Clusters of galaxies" (pp. 617-619) + Fig. 24.18 (p. 621)]

(d) Cosmic distance scale IV: Hubble's law - the ultimate tool [Section 24.3 (pp. 619-621)]

Week 14: Active Galaxies, Quasars; Dark Matter

(a) Active galactic nuclei, quasars [Section 24.4 (pp. 622-629)]

(b) The engine of an active galaxy [Section 24.5 (pp. 630-634)]

(c) Dark matter in the universe [Section 25.1 (640-642)]

(d) Galactic evolution: of our own [Section 23.4 (pp. 589-590)]

(e) Galactic evolution: in general [Section 25.3 (pp. 645-650)]

(f) Black Holes in Galaxies: a simplified unified theory of galaxy formation and evolution [Section 25.4 (pp. 652-656)]

Week 15: Cosmology; Dark Energy; Early Universe; Review

(a) Largest scales; Cosmological principle [Sections 25.5. Sections "Clusters of Galaxies" and "Redshift Surveys" (pp. 656-658); 26.1 (pp. 668-669)]

(b) Expanding universe; Big Bang [Section 26.2 (pp. 670-673)]

(c) Possible scenarios (by curvature); Accelerated Expansion: Dark Energy [Sections 26.3,26.4,26.5,26.6 (pp. 673-683); **MP** 26-1 (p. 677); **DI** 26-1 (p. 681)]

(d) Cosmic microwave background (CMB) radiation [Section 26.7 (pp. 683-685)]

(e) **Optional:** The early universe [Sections 27.1,27.2,27.3,27.4,27.5 (pp. 690-706); **MP** 16-1 (p. 413); **MP** 27-1 (p. 694)]

(f) **Optional:** Exotic topics: *Of course, whatever is discussed here will be for your general culture, not for exams!*