ASTR 501/701 Stars & Exoplanet Atmospheres: spring 2015

TTh 12:30-13:45, Phillips 208

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1 Course Description

ASTR 501 examines the structure and evolution of stars from pre-main sequence youth to death, as individuals and as a population. Thermonuclear fusion and atmospheric energy transfer processes bound stellar volumes; information from these regions comes to us as neutrinos and photons, respectively. The course will generalize energy transfer to treat exoplanetary atmospheres illuminated and viewed from above. It follows stellar structure as constituent gas clouds collapse under gravity; the ISM course details earlier times. We barely consider rare relativistic end-products such as neutron stars and black holes that are detailed elsewhere and benefit from a course on general relativity.

ASTR 701 adds an extra hour for graduate students, to address more advanced topics and readings from current scientific literature.

2 Course Goals

2.1 Required Co-requisites

PHYS 331 (numerical techniques) and PHYS 341 (Thermal physics) are co-requisites, so the course is appropriate for physics juniors and seniors with developing computer skills. From thermal, we use partition functions, chemical potentials, detailed balance equations, degenerate gases, specific heats, entropy, various equations of state, and state diagrams.

I recommend the free academic Anaconda python installation (store.continuum.io/cshop/academicanaconda); install the 2.7 used by astronomers not 3. You need a Mac, Windows or Linux laptop w/ python core + packages scipy (includes numpy), astropy, dislin (www.dislin.com), quantities. The last 2 will require manual installation at the first class where I will also check/confirm your python and ipython installations; homework will only be accepted as ipython notebooks (ipython.org/notebook.html) using the template provided at the course sakai site and uploaded there. Necessary codes will be distributed from this site. All results must include the physical unit, properly reduced as we will discuss in class, because an important part of learning astrophysics is to develop a feel for plausible magnitudes of results. You will come of feel accomplished in astrophysics by exploiting opportunities to apply and refine your growing knowledge of mechanics, E&M, QM, and relativity.

2.2 Acquired Skills

- Learn physics of nuclear fusion processes and outcomes.
- Model analytically and w/ computer codes radiative transfer through static atmospheres illuminated from below (stars) and above (exoplanets).
- Model analytically and w/ computer codes the changes in stellar interior structure as the star evolves.
- Enhance python programming skills, e.g. numerical solution of coupled differential equations, use of Laplace and Fourier transforms, plotting of results, automated unit/error propagation.

3 Assessment and Policies

1/3 each on weekly homeworks released from sakai and closed book(s) mid-term test; semester project; comprehensive closed book 3-hr final exam. Mid-term make-up allowed only with MD permission slip.

3.1 Late Policy

Unless you arrange with the instructor before the due date or have an official University excused absence, you will lose 10% of total points daily for a late assignment. No credit for homewok submitted after the due date.

3.2 Attendance Policy

Please attend class, the instructor will not spend it reading Powerpoints; if you find that classes are not useful, suggest what the instructor can do to make material and its presentation more stimulating. Excused absences can be granted only in advance except in cases of sudden illness or other emergency.

3.3 Honor Code Policy

The Honor code and Campus Code, embodying the ideals of academic honesty, integrity and responsible citizenship, have for over 100 years governed the performance of all academic work and student conduct at the University. Your participation in this course is with the expectation that your work will be completed in full observance of the Honor Code. If you have any questions about the Honor Code, please consult with someone in the Office of the Student Attorney General or the Office of the Dean of Students.

Students are expected to abide by the Honor Code in all classroom activities. Collaboration is explicitly allowed on assignments that are designated as group submissions. Discussion with other students prior to submitting an individual answer is also permitted on homework exercises, as described above. Otherwise, all work must be your own and is subject to the UNC Honor code.

3.4 Syllabus Changes

The instructor reserves the right to change the syllabus, including due dates and test date. Changes will be announced as early as possible on the sakai site and in class.

4 Required Textbooks (∼$150 total)

1. *Introduction to Stellar Astrophysics*, LeBlanc, 2010, Wiley, $35 Amazon used paperback. [SA in reading schedule]
2. *Exoplanet Atmospheres*, Seager, 2010, Princeton U. Press, $33 Amazon new paperback. [EA]
3. *Astronomical Spectroscopy*, 2011 (2nd ed), Tennyson, World Scientific, $35 Amazon new paperback. [AS]
4. *Evolution of Stars and Stellar Populations*, 2005, Salaris & Cassisi, Wiley, $43 Amazon used paperback [ES]

5 Additional Reference for 701 only

- *The Observation and Analysis of Stellar Photospheres*, 2008 (3rd ed), Gray, Cambridge U. Press, $73 Amazon used paperback

6 Lecture Topics and Tentative Schedule

Read [] prior to week of classes; explicit sections to work through will be given at the start of each week. Keep up with the extensive reading, and start assigned problems as soon as they are assigned. There is much material in this course, physics interspersed with numerical techniques and applictions.

- 1/13 [AS 1 & 2, EA 1 & 2, SA 1] Intensity, Flux, Black Body radiation, Boltzmann & Saha equations
- 2/20 [AS 3 & 4, EA 3 & 4] Review of atomic hydrogen, complex atoms, atmospheric temperatures, albedos, flux ratios
- 2/27 [AS 5 & 6, EA 5, SA 3] Helium, alkali atoms, radiative transfer in stars
- 2/3 [SA 4, EA 6] stellar atmospheres, solutions of radiative transfer
- 2/10 [AS 7, 8, 9] Magnetic fields, optically thin nebular spectra in optical and X-rays
- 2/17 [AS 10, 11, 12, EA 8] Molecular spectra
- 2/24 [AS 13, EA 9, 10, 11] Diatomic molecules, vertical structure of planetary atmospheres, atmospheric circulation, biosignatures
- 3/3 [SA 5] Stellar interiors
- **3/10 Spring break, no classes. In class mid-term will be held near spring break.**
- 3/17 [ES 5, SA 6] H burning in core and shell
- 3/24 [ES 6] He burning
- 3/31 [ES 7] Advanced evolutionary phases

- 4/7 [ES 8] From theory to observations
- 4/14 [ES 9] Simple stellar populations
- 4/21 [ES 10] Composite & unresolved stellar populations
- **5/1, 12:30 pm FINAL EXAM**