Physics 430: Astrophysics

Spring 2019

Meeting: Trexler 272 — Time: MWF 12:00 – 1:00 PM

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Office Hours: W 1.15 – 4.00pm
F 1.00 – 2.30pm, or by appt.

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Required Readings: *Astrophysics In a Nutshell*, Dan Maoz; ISBN 0-495-01578-4
Heart of Darkness, Jeremiah Ostriker & Simon Mitton; ISBN 978-0-691-13430-7

Required Prerequisites: Physics 203

I. Components of Learning

There are several factors that make a course "good" (by good, I mean a healthy combination of the intellectual and the affective). Good courses are also clear about their essential components. Below is an attempt to be clear about how will I operate within PHYS 430, as well as my expectations of a student who is enrolled in PHYS 430.

Descriptions

Aspiration: Perhaps no other field demands such a comprehensive grasp of all realms of physical law than astrophysics. While an understanding of classical mechanics and electrodynamics are quite obvious, it is not commonly understood that most astrophysical phenomena also involve quantum, chemical, and statistical physics. It is somewhat daunting, but all the more invigorating, to think that these normal segregated branches of physics come together in the examination of the heavens. Furthermore, our capabilities to make order-of-magnitude estimates are taxed to the hilt when considering the field of astrophysics. Yet, these are the things of which physicists are made. I hope you are excited to have the opportunity to grow in these needed ways through the coursework this semester.

Expected Learning Objectives: Successful students will–

(1) describe the basic evolutionary process for main-sequence stars.

(2) calculate the masses and luminosities from general scaling relations for main-sequence evolution.

(3) synthesize basic quantum phenomena to explain stellar processes like energy generation, cooling, and late-evolution, pressure support.

(4) analyze observations of interacting binary systems to determine stellar masses and predict evolutionary patterns.

(5) connect individual steps in stellar formation into a continuous process of cloud collapse and restabilization.

(6) explain 3 physical observations that lead to a deduction of the structure of the Milky Way galaxy.

(7) describe the basic observations of galaxy clusters that lead to the current coherent astrophysical picture.

(8) analyze the current extragalactic distance ladder and provide an informed opinion about its uncertainties.

(9) explain the theoretical framework and observational confirmations for the standard big bang cosmology.

(10) list three open questions related to observational proofs of dark matter and dark energy.

Attendance: Although roll will not be taken, daily attendance is expected. Due to the mathematically rigorous nature of the course, you may not miss more than *four* classes without a legal excuse (court, hospital, police, etc.). Late arrivals greater than 10 minutes will constitute an official absence. The fifth absence for which there is no legal excuse will constitute your (forced) withdrawal from the course.

Office Hours: Please take advantage of the office hours prescribed above, or make an appointment with me. Drop-ins (aka. 'academic drive-bys') are at the total mercy of my daily schedule, for which I have the freedom to say, "I'm too busy."

Inquire (`NQR`**):** I use the `NQR` environment extensively to place notes, announcements, assignments, *proofs*, *solutions*, links, and other course documents. Please do NOT forget to check `NQR` before you come to class or if you have a question about previous assignments.

Academic Integrity: I want to foster a mutual respect for the classroom hours that we have together. In light of this, please remember to turn off cell phones, PDAs, etc. during the class and come prepared.
Refer to the "Academic Integrity" page on the RC website–
`https://www.roanoke.edu/inside/a-z_index/academic_affairs/academic_integrity`
Included here is an explanation of how violations of the College's academic integrity policy are handled.

Grades: Standard letter grades (A–F) are assigned according to the following scale for this course: "A"(91–100), "B+"(88–90), "B"(83–87), "B–"(80–82), "C+"(78–79), "C"(74–78), "C–"(70-73), "D"(60– 69), "F"(< 60).

II. Modes of Learning

Rubric

Your grade is determined according to the following distribution:

Exams (2, take-home)	30%	Problem Sets	25%
Final (in-class)	15%	On-line Quiz	12%
In-class Quiz ("weekly")	13%	Participation	5%

Descriptions

Exams: Two exams are designed for completion over a weekend without hindrance of class periods. Because the exams are take-home, you are trusted NOT to use the following aids: other persons, internet, solution manuals for textbooks. Beyond that, I encourage you to use notes, books, etc. The final exam will be given in class and focus on newer material, but it will also incorporate some cumulative material. Make-up exams will

only be allowed as a result of a discussion with me **beforehand** or a note related to the emergency (death, hospitalization, misdemeanor, etc.) *signed* by a governing official (medical doctor, parent, law enforcer, etc.).

Problem Sets: Un-/assigned problems (like those in the problem sets) are "**when and where**" you will learn the course material. For better and for worse, there is no way to learn the depth of the material within the one-hour sessions that we will have together. Due to the nature of problem solving, I expect that you will work together *toward* a solution. However, I also expect that you will create an original solution to each assigned problem. Substitutions and simplifications should **NOT** be left to the "reader" (that's me) to figure out. If necessary, words and phrases need to be properly placed so that I can follow your train of thought. Problem sets are your final draft essays and/or compositions that display the fruit of your higher-level critical thinking skills, so you need to view them in that light. If you do not, I will return them to you for completion. NOTE: the submitted problems are ALMOST EQUAL in weight to the two exams.

In-class Quizzes: Weekly quizzes (FRIs) are completed individually in-class and graded. The quiz will consist of one partial problem from the problem set and/or class discussion, which contain the *more* important concepts and/or phenomena.

On-line Quizzes: Weekly quizzes (TUE and THU nights) are completed on-line and graded within the NQR environment. The quizzes will consist of a few multiple choice questions from the required reading. There will be page numbers announced and the quiz will be open-book.

Participation: There are lots of opportunities to participate within the course. Your attendance in class, your collaboration during group assignments, and your responsiveness during discussion are all forms of "participation". The completion of all on-line assignments, the watching of any audio-video lectures, and the submission of all problem sets, regardless of the grade, are also forms of participation. Your TWO conversation reviews (or similar talks) are included here also. Please don't miss your chance to learn.

III. Daily Course Outline

In what follows, you will see the plan for working through the course. Each course meeting provides a section of the text, a conceptual topic, and a homework problem to reinforce the topic. Quizzes and Exams are also marked on the course outline, so please refer to it often. The **bold-faced** class periods require the watching of an audio-video lecture BEFORE class. The *italics* class periods denote a class discussion on the Heart of Darkness and an in-class quiz. If there are deviations from the following outline, I will certainly draw your attention to them.

430: Astrophysics Outline, SPR 2019

Wk	Date	Chapter	Topic	HW	In-Class
	14-Jan	1. Introduction	Units, Conversions, Dimensional Analysis	Planck	
1	16-Jan		1.1 Observational Techniques	1.1	1.2
	18-Jan	2. Stellar	2.1 Blackbody Radiation		2.1
	21-Jan	Observations	2.2 Measurement of Stellar Parameters	2.3	
2	23-Jan		2.3 Hertzsprung-Russell Diagram	2.5	2.4
	25-Jan		*Heart of Darkness: Preface and Prologue*		
	28-Jan	3. Stellar Physics	3.1 Hydrostatic Equilibrium/ Virial Theorem	3.2	
3	30-Jan		3.2-3 Mass Continuity & Radiative Transport	3.4	3.1
	1-Feb		*Heart of Darkness: 1, Einstein's Toolkit*		3.3
	4-Feb		3.4-5 E Conservation & Stellar Structure	3.5	
4	6-Feb		3.6-7 Equations of State & Opacity	3.6	3.9
	8-Feb		*Heart of Darkness: 2, Realm of the Nebulae*		3.7
	11-Feb		3.8 Scaling Relations for MS Stars		
	13-Feb		3.9—3.12 Internal Stellar Processes		
5				Take Home	3.8
	15-Feb	4. Stellar	*Heart of Darkness: 3, Let's Do Cosmology!*	MT Ex 1	
	18-Feb	Evolution	4.1 Stellar Evolution		
6	20-Feb		4.2 White Dwarfs		4.2
	22-Feb		4.3 Supernovae and Neutron Stars	4.1	4.4
	25-Feb		4.4 Pulsars & Supernova Remnants	4.3	
7	27-Feb		4.5—4.6 Black Holes & Interacting Systems	4.6	4.7
	1-Mar		*Heart of Darkness: 4, Discovering Big Bang*		4.5
	4-Mar				
8	6-Mar	No Classes – Spring Break			
	8-Mar				

9	11-Mar 13-Mar 15-Mar	5. Formation, HII/Interstellar Regions	5.1—5.2 Cloud Collapse, Formation, & HII 5.3—5.4 ISM Components & Dynamics *Heart of Darkness: 5, Origin of Structure*	4.9 5.1 5.2	 5.3 5.4
10	18-Mar 20-Mar 22-Mar	6. Milky Way & Galaxies	6.1—6.2 MWG Structure & Demographics 6.3—6.4 AGN, Quasars, Groups, Clusters *Heart of Darkness: 6, Dark Matter*	 Take Home MT Ex 2	 6.4 6.6
11	25-Mar 27-Mar 29-Mar	7. Cosmology: Observations	7.1-2 Olbers Paradox & Distance Scales 7.3-4 Hubble's Law & Age of the Universe *Heart of Darkness: 7, Dark Energy*	 7.2	 7.1 7.3
12	1-Apr 3-Apr 5-Apr	8. Big Bang Cosmology	8.1 Friedman-Robertson-Walker Metric 8.2 Friedman Equations *Heart of Darkness: 8, The Modern Paradigm*	HO s 8.1 	 8.2 8.2
13	8-Apr 10-Apr 12-Apr		8.3—8.4 History & Future of the Universe 8.5 Dark Energy & the Accelerating Universe *Heart of Darkness: 9, The Frontier*	8.4 	 8.3 8.5
14	15-Apr 17-Apr 19-Apr	9. Tests & Probes of BB	9.1 Cosmological Redshift & Hubble's Law 9.2 The Cosmic Microwave Background No Classes – Good Friday	9.1	 9.2
15	22-Apr	Cosmology	9.3 Anisotropy of the CMB		9.8
	24-Apr		In-class, Non-cumulative Final Exam 8.30 – 11.30		