

ASTR398B: Black Holes (Spring 2017; Reynolds)



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Office: PSC1154

Lectures : Tuesday and Thursday 2.00-3.15pm; CSS2400

Office hours: 10-11am Thursday, my office (PSC1154)

Grader : Blake Hartley (bth@astro.umd.edu)

Course description

Black holes are the most exotic prediction of Einstein's Theory of General Relativity and, amazingly, the Universe seems to manufacture these bizarre objects in copious numbers. As well as being the ultimate laboratory for studying the nature of space and time, they drive some of the most energetic and extreme phenomena known to astronomers (with quasars and gamma-ray bursts being just a couple of examples.)

Astronomy 398B is an introduction to the physics and astrophysics of black holes. We start by examining the basic physics of black holes, which fundamentally means understanding gravity. We then look at the nature of stellar-mass black holes (that result from the death of stars) and supermassive black holes (whose origin is closely tied to the formation of the galaxies themselves). We will discuss the fairly recent realization that black holes may be

crucial agents for regulating the growth of galaxies. Finally, we dive into the realm of theoretical physics and probe how black holes may provide a route for uncovering new laws of physics governing the structure of space and time.

The course website is at

http://www.astro.umd.edu/~chris/Teaching/ASTR398B_Spring_2017/ASTR398B_Spring_2017.html

It will contain links to course information, and copies of past homeworks and lecture notes. Course materials are also available via ELMS.

Course Pre-requisites

It is assumed that you have completed the CORE Distributive Studies requirement in Mathematics and Sciences, or that you have completed the General Education Fundamental Studies requirement in Mathematics. We also assume that you have completed one of the Introduction to Astronomy courses (ASTR100, ASTR101 or equivalent). While this is a non-technical course on black holes, quantitative reasoning and some mathematics will be required.

Course expectations

Attendance: In order to successfully complete this course, I expect you to attend class 2 times a week. If you have to miss a lecture, please be sure to obtain a copy of the notes (either from another student, the web-site, or from me) and make sure that you understand what you missed. There will also be times when I will ask for class participation either in small groups or as individuals.

Preparation: I expect you to be prepared to work. We will be covering some fascinating but very challenging concepts - you will understand this material much more easily if you preview the recommended chapter of the course book ahead of time, as well as giving it a more careful read after the lecture. You also should review your class notes sometime before the next lecture to make sure everything is clear. I encourage you to ask questions in the lectures or during my office hours.

Study Habits: Study wisely and ask for help if you need it. It is better to keep up with the material on a daily basis than cram the night before the exam. I encourage you to chat about problems with your friends and classmates – you will learn a huge amount from trying to explain confusing issues to each other. ***However, please keep in mind that all graded materials, including class-assignments and home-works, must be your own thoughts in your own words.***

Grading

Grades are based on homeworks, class participation, one midterm exam, and the final exam. These three components contribute to the grade according to the following weights:

Homeworks	30%
Participation	10%
Midterm	30%
Final	30%

Your percentage grade will be converted to a letter grade. Below are the guaranteed grade boundaries – any “curving” will only be in the direction of giving you a better grade than indicated:

A	>90%
B	80—90%
C	70—80%
D	60—70%
F	<60%

Midterm exam

There will be one in-class examination on 16-March-2017. This exam will be closed book. The exam will consist of a section of short answer questions, followed by longer essay and problem solving questions. The midterm exam is a “**major scheduled grading event**” and is covered by the relevant University rules for excused absence. In essence, you must inform me in a timely manner and provide documentation if you need to miss this exam (a self-signed note is not sufficient).

If, for whatever reason, the University is officially closed on the day of the exam, the exam will be re-scheduled for the next lecture date.

Final exam

As per the University rules, the final exam for this course will be held on Wednesday 17th May 2017 at 10.30am-12.30pm in room CSS2400. The final exam is cumulative in the sense that it will cover all material discussed in this course. The format of the final exam will be the same as the midterm exam, with a section of short answer questions and a section of longer essay or problem solving questions. Again, the final exam is a “**major scheduled grading event**” and is covered by the relevant rules for excused absence (see above).

Homeworks

Homework will typically be set once per week, with a due date one week after it is assigned. Odd numbered homeworks (HW#1, HW#3 etc.) will typically be “enrichment exercises” consisting of an online and/or reading assignment requiring a short written response via ELMS. Even numbered homeworks (HW#2, HW#4 etc.) will be problem sets that require submitting in a hard copy in class on the due date. Late homeworks will be accepted for a week after the due-date and will be subjected to a penalty of up to 30%. If you cannot make it to class when a hard-copy homework is due, you should either ask a friend/classmate to hand it in for you, or make sure that it gets to me (room PSC1154) **before** the time that it is due. If you have a valid emergency that prevents you from making a homework deadline, you should make all reasonable efforts to contact me before the due date telling me the nature of the emergency.

If, for whatever reason, the University is officially closed on the day of the due date, the due date will be moved to the next lecture.

Excused Absences and Student Grievance Policies

The University has recently changed the excuse absence and student grievance policies. The new policies can be found at

<http://www.president.umd.edu/administration/policies/section-v-student-affairs/v-100g>

<http://president.umd.edu/administration/policies/section-v-student-affairs/v-100a-0>

These are substantial and nuanced documents - please familiarize yourself with them.

University Course Related Policies

The Office of Undergraduate Studies has developed a student-oriented webpage which brings together information about relevant undergraduate student/course policies and procedures:

<http://www.ugst.umd.edu/courserelatedpolicies.html>

This is important information with which you should familiarize yourself.

Preliminary course outline

CLASSICAL PHYSICS OF BLACK HOLES

26-Jan-2017	Introduction to the course
31-Jan	Newton's Laws of Motion in Three Acts
2-Feb	Newtonian Gravity
7-Feb	Einstein's Theory of Special Relativity I
9-Feb	Einstein's Theory of Special Relativity II
14-Feb	Einstein's Theory of General Relativity I
16-Feb	Einstein's Theory of General Relativity II
21-Feb	Schwarzschild Black Holes
23-Feb	Kerr Black Holes

STELLAR MASS BLACK HOLES

28-Feb	The Life and Death of Stars
2-Mar	Neutron Stars and Pulsars
7-Mar	X-ray Binaries and the Observational Discovery of Black Holes
9-Mar	Gamma-Ray Bursts
14-Mar	Accretion Disks
16-Mar	MIDTERM EXAM
21-Mar	<i>SPRING BREAK</i>
23-Mar	<i>SPRING BREAK</i>

SUPERMASSIVE BLACK HOLES

28-Mar	Discovery of Quasars
30-Mar	Active Galactic Nuclei
4-Apr	AGN Jets
6-Apr	Our Galactic Center
11-Apr	AGN Feedback on Galaxies I
13-Apr	AGN Feedback on Galaxies II
18-Apr	Origin of Supermassive Black Holes
20-Apr	Observing the Effects of GR Around Black Holes

BLACK HOLES AS LABORATORIES OF FUNDAMENTAL PHYSICS

25-Apr	Gravitational Waves I
27-Apr	Gravitational Waves II
2-May	Quantum Physics and Black Hole Evaporation
4-May	Quantum Entanglement and the Black Hole Information Paradox
9-May	Special Topic Lecture
11-May	Review session

FINAL EXAM : 17-May-2017, 10.30am-12.30pm