Relativity and Black Holes — Syllabus

Unofficial/Short Course Title: Black Holes. Fall 2024. Deep Springs. ***Prof. Brian Hill****.*

Overview

More than anyone else since Einstein, John Archibald Wheeler has influenced our understanding of spacetime. He is a co-author (with Misner, Thorne, and Taylor, among others) on the greatest textbooks in the field and his students have gone on to greatly advance physics. We will work through Taylor and Wheeler's descriptions of two things: (1) special relativity, which is how space and time are related in the absence of gravity, (2) the behavior of spacetime around a black hole. The latter is also entirely relevant for tight orbits around ordinary stars, and in fact the first evidence for general relativity listed by Einstein was the explanation of the deviation of Mercury's orbit from the ellipse expected from Newtonian gravity. The intertwining of space and time is highly counterintuitive. The intertwined fabric is called "spacetime." Our story will begin with Galileo who formulated the version of relativity that Newton built upon, and which lasted for almost three centuries until Lorentz, Poincaré, and Einstein formulated special relativity. Our tale will get all the way to Einstein's General Relativity and we will explore Schwarzschild's exact solution of Einstein's equations surrounding a black hole.

Prerequisite / Joining the Class

I will use mathematics that is commonly taught in AP Calculus. If this is material you have gotten rusty on, I will remind you of the key results as we use them.

Texts

We are going to use two texts. Very generously, Taylor, Wheeler, and Bertschinger have made PDFs of the textbooks we will be using completely free:

- ***Spacetime Physics, 2nd Edition*****, https://www.eftaylor.com/spacetimephysics/**
- ***Exploring Black Holes, 2nd Edition*****, https://www.eftaylor.com/exploringblackholes/**

Grading

- 45% assignments
- 15% (45% total) for each of three exams, dates to be determined, but coming at about the 5th, 9th, and 14th week of classes
- 10% preparation for class and leadership of course

Problem Sets / Handouts / Being Neat and Organized

There will be problem sets due almost every class, limited only by how quickly I can assign, write solutions, and grade. The more problems you do the better. In addition to the problem sets and their solutions, there will be exams and exam solutions. To be organized, locate a three-ring binder and a three-ring hole punch, and file everything chronologically. Actually, reverse-chronological is the most convenient, because you then naturally open your binder to what you are currently working on. Problem sets should be *neat* and on standard 8 1/2 x 11 paper. Multi-page problem sets (and most will be multi-page) should be stapled. The nicest technical work is facilitated by engineering pads, such as these **Roaring Spring Engineering Pads at Amazon** (which are pretty expensive unless you buy by the case), and done with a mechanical pencil, a ruler, and an eraser at hand.

Absences (and late work)

The College's policies on absences (and late work) are applicable. Refer to the Deep Springs Handbook.