S15662: Relativity and Black Holes

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1 Course Description

Ever wanted to learn about how time space bend into each other? Want to get a semi-technical introduction to one of the pillars of modern physics?

Come take a whirlwind tour of Special Relativity, General Relativity, and Black Holes. We'll introduce just enough math so you can do some calculations on your own. Along the way, we'll learn about time dilation, length contraction, how matter affects spacetime, and even what's "inside" a black hole.

Prerequisites: Calculus I (differentiation and the chain rule), Trigonometry, Some High-School Physics (Newton's 3rd law and law of gravitation), Some prior familiarity with vectors and matricies will be helpful but not necessary

2 Syllabus

- Week 1: Special Relativity: Coordinate Transforms, Time dilation/Length contraction, and Matricies
- Week 2: Special Relativity: Spacetime interval, and the Minkowski metric, 4-vectors
- Week 3: Differential Geometry: General Coordinates, and the Spacetime metric
- Week 4: General Relativity: Gravitational "force," Christoffel symbols, and Covariant and Absolute derivatives
- Week 5: Black Holes: The Schwarz metric, gravitational Time dilation/Length contraction, Newtonian gravity
- Week 6: General Relativity: Einstein Field Equations, Stress-Energy Tensor, Gravitational Energy

3 Class Structure and Logistics

Class will begin and end on MIT time (2:35pm-3:55pm EST) with a short break in the middle. Please log in no more than 5 minutes before the official 2:30pm start time. When in class, remain muted until a question is asked, and use the "raise hand" function if you have a question while lecture is ongoing. Each class will begin with brief review of previous concepts and (selected) answers to class questions from the previous section

In the days following lecture, a weekly e-mail will be sent to the whole class asking if there were any questions from lecture or points that needed more clarification. The message will typically include partial notes roughly following the course direction. Please reply to the e-mail directly with questions from lecture, however refrain from asking questions pertaining to aspects of the shard notes not covered in lecture. Be aware that, as per MIT minors policy, no individual communication is allowed, so **no questions** of any kind will be answered via e-mail. Class questions will be addressed in lecture the next session

4 Supplementary Resources

Here is a small selection of books and courses that may help with certain concepts covered or allow for further investigation:

- Suskind lectures on Special Relativity (Here)
- Suskind lectures on General relativity (Here)
- *Special Relativity for the Enthusiastic Beginner*, D. Morin
- *Exploring Black Holes*, E. Taylor and J. Wheeler