General Relativity, spring 2020

Course information

Course book
James B. Hartle: *Gravity. An introduction to Einstein's general relativity* (2003)

(Avoid buying Pearson's "New International Edition"; for more information on this, including relevant links, see the webpage below.)

Course webpage

https://sorenholst.se/general-relativity

Here you find, for example, answers to the recommended problems and an errata to the course book. After each lecture, I will also make lecture notes available here. Often my lecture notes will follow the book, but sometimes you will find that Hartle's book and my notes provide slightly different perspectives. In some cases my notes contain material that is not in the book at all, but in those cases I will let you know.

Course plan

On the webpage you also find a preliminary course plan. For each lecture, there is some recommended reading in the book, as well as some recommended problems.

Some of the recommended reading is in parenthesis. These parts are "extensive reading". That is, I recommend that you read these sections, but I will not discuss them during the lecture, we will not solve any problems related to them, and they will not be examined.

As for the recommended problems – try to do all or at least most of them! They are carefully selected to be interesting and they constitute an integral part in order to master the content of the course. Some of the hand in assignments will be closely related to the problems, so solving the recommended problems will make it easier for you to solve the home assignments. You will get help and support with the recommended problems during the problem solving sessions led by Marcus Högås.

As you can see in the course plan, we will jump a little bit in the book (in accordance with one of the reading schemes that Hartle himself suggests in one of the appendices). We start out by reviewing some important concepts from Special Relativity, and we show that Special Relativity together with the Equivalence Principle *requires* that we describe gravity by means of a curved spacetime. We explain how to do that by means of a *metric*, and study the Schwarzschild geometry as an example. Only then we introduce some of the more general mathematical concepts of differential geometry, like *parallel transport*, *the covariant derivative* and *the Riemann curvature tensor*. We also introduce *the stress energy tensor*, enabling us – at last! – to write down *Einstein's equation* coupling the energy content of the universe to its spacetime curvature. Finally, we study some of the most important applications of the theory: *black holes*, *gravitational waves* and *cosmology*.

Special topic session

There will be one “Special topic session”, May 28, on Black hole thermodynamics. Here we will try to understand some hotly debated issues, for example on black hole entropy and the information paradox.

Exam

The course content will be examined in two ways: through home assignments and through an oral exam at the end of the course. For more information about the examination, see the document available on the webpage.

Contact information

If you have any questions concerning the course or its content, do not hesitate to contact me! Here is my contact information:

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