University of Glasgow

Department of Physics and Astronomy

Session 2008-09: A45M General Relativity & Gravitation II

Welcome to General Relativity and Gravitation II. In these 11 lectures we will apply the mathematical and physical machinery developed in GRG-I to explore how general relativity influences a range of astrophysical phenomena – from the interior structure of stars to the geometry of the Universe.

The good news (well, depending on your point of view!) is that I won't be introducing any more new mathematical methods in this course; GRG-I has already equipped you with all the tools of tensor algebra and calculus that you'll need to make sense of the syllabus of GRG-II.

The maybe not-so-good news is that we will be making extensive use of these mathematical tools throughout GRG-II, so if you haven't yet had the chance to get on top of the material covered in GRG-I then it's best not to wait too long before you start. To help with this, I will begin my GRG-II notes by providing a summary of the key mathematical and physical ideas which you should have brought with you from GRG-I. I will also make available example sheets (some of which were incorporated in Norman's examples) covering the material of GRG-I, which I have used when I have taught GRG-I in the past. These may help with your revision by giving you a larger pool of example questions with which to hone your tensor skills!

I also intend to provide detailed printed notes for each section of the course. These should not be seen as a substitute for attending the lectures themselves; nor should they discourage you

from consulting other textbooks to supplement the lecture material. I will follow quite closely the relevant content of Bernard Schutz' textbook "A First Course in General Relativity" (henceforth referred to as 'Green Schutz') and it is highly recommended – although not essential – that you take a look at Green Schutz. As Norman has also pointed out, however, it's very useful in studying GR to consult as many different sources as possible.

Note that throughout the course I will generally adopt the same metric signature as Green Schutz – i.e. writing the Minkowski metric of special relativity (with $c = 1$) as:-

$$ds^2 = -dt^2 + dx^2 + dy^2 + dz^2$$

This signature may differ from the signature adopted by Norman in GRG-I (although I don't think it does) but even if this is the case it should be seen as a virtue rather than some sinister plot to confuse you. It is important to appreciate that the choice of metric signature is simply a convention, and that one should be comfortable with different conventions: e.g. $(-,+,+,+)$ and $(+,-,-,-)$. Note also that some authors introduce a new imaginary time coordinate, ict, in order to obtain a $(+,+,+,+)$ metric signature. What we learn from studying relativity is that space and time coordinates are merely frame-dependent labels, so we should not get too attached to a particular signature or to a particular choice of coordinate system. Indeed, when we consider later in GRG-II the spacetime inside the event horizon of a black hole, we will see that the 'everyday' meanings of these coordinate labels can be completely misleading.

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January 2009