The Theory of Relativity: Special and General

George Efstathiou

CONTENTS

How to use these notes

There are lots of textbooks on special and general relativity. My personal favourite is Weinberg's book *Gravitation and Cosmology* (John Wiley and Sons). This book is a bit old now and goes to a higher level than is required for this course. It is also expensive. For this course I recommend d'Inverno's book *Introducing Einstein's Relativity* (Oxford University Press) . It is cheap and well written. However, it approaches the subject from an applied mathematician's point of view whereas I prefer to adopt a more intuitive 'physics' approach. I have therefore written these notes for three purposes. Firstly, I introduce the mathematics *only as it is needed.* The physics behind the theory drives the need for mathematics, not the other way round. Secondly, although I prefer a 'physical' approach to the subject, some of the advanced mathematical techniques developed by professional relativists (*e.g.* Penrose diagrams) are easy to understand and deserve exposure to an undergraduate audience. These advanced techniques can help you understand some of the more bizarre aspects of the theory that are often referred to in programmes like Star Trek. For example: What happens if you fall into a black hole? What is a wormhole? Can you travel to another Universe? Are these ideas pure science fiction, or do they have a basis in physical theory? Thirdly, General Relativity involves a lot of tedious algebra. Rather than plough through this algebra on the blackboard, which would bore you and take a long time, you can refer to these notes. Most of the algebra is worked through here. You will have seen cookery programmes where the cook prepares a dish, pops it in the oven, and then immediately pulls out another one saying 'here is one that I prepared earlier'. That is how I want to approach the lectures. Instead of ploughing through complicated algebra, I will sometimes work partially through examples and then pull out results 'ready made' from these notes. There is no sleight of hand, the algebra is done in these notes. To get the most out of these notes, I would like you *to work through all of the algebra.* If you reproduce the calculations in these notes, you will gain experience in handling tensors and in solving problems in Special and General Relativity. In my experience, the only way of gaining an understanding of *any* branch of physics is by working through lots of examples.