

Preface

Eleven years after Einstein's theory of special relativity completely changed our understanding of the relationship between space and time [Einstein (1905)], his theory of general relativity revolutionized our understanding of how mass and energy change the underlying space-time structure of the physical universe [Einstein (1916)].

Some time ago I had to learn general relativity in connection with my research. I had great difficulty listening to the experts and understanding what they were doing. I decided I had to teach the subject to myself, and I proceeded to do so. Much later, I converted my notes to a semester course at William and Mary, which was offered three times. It was aimed at physics graduate students, but many undergraduates participated, and excelled. The students seemed to learn from it and enjoy it, and the outcome was very satisfying. I decided that I would convert these lectures into a book entitled *Introduction to General Relativity*.

General relativity is a difficult subject for two reasons. The first is that the math is unfamiliar to most physics students, and the second is that since the four-dimensional coordinate system has no intrinsic meaning, it is difficult to get at the physical interpretation and physical consequences of any result. The goals of the present text are as follows:

- The book is aimed at physics graduate students and advanced undergraduates. Only a working knowledge of classical lagrangian mechanics is assumed,¹ although an acquaintance with special relativity will make the book more meaningful. Within this framework, the material is self-contained;
- The necessary mathematics is developed within the context of a

¹As presented, for example, in [Fetter and Walecka (2003)].

concrete physical problem — that of a point mass constrained to move without friction on an arbitrarily shaped two-dimensional surface;

- A strong emphasis is placed on the physical interpretation and physical consequences in all applications;
- The book is not meant to be a weighty tome for experts (indeed, I could not write one), but, in my opinion, most of the interesting applications of GR are covered;
- The final “Special Topics” chapter takes the reader up to a few areas of active research.

At the end of the course at William and Mary, students selected a topic of current interest, wrote a term paper, and then gave a talk to the class in the format of a contributed session of an American Physical Society meeting (complete with abstract). I was amazed and pleased with the level at which the students were able to perform. It is my sincere hope that this text will provide useful background for other young people and aid them in their exploration of many of the fascinating modern developments based on Einstein’s theory of general relativity.

An extensive bibliography has not been attempted, although most of the comparable and more advanced texts are referenced, as are relevant websites. Since general relativity is an old subject, no effort has been made to trace the origin of the examples and problems, many of which are modified versions of those in the list of texts and monographs.

I was delighted when World Scientific Publishing Company, which had done an exceptional job with two of my previous books, showed enthusiasm for publishing this new one. I would like to thank Dr. K. K. Phua, Executive Chairman of World Scientific Publishing Company, and my editor Ms. Lakshmi Narayanan, for their help and support on this project.

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