



“Physics in Canada”  
Book Review

“La Physique au Canada”  
Critique de livre

**A Relativist’s Toolkit: The Mathematics of Black-Hole Mechanics**, *Eric Poisson*, Cambridge University Press, 2004, pp: 233, ISBN 0521830915 (hbk); Price: US\$60.

As the author explains in the preface, this text is directed at students already familiar with general relativity at the introductory level but not yet so advanced as to have mastered the classic *General Relativity* by Robert Wald (1984 Chicago, IL: University of Chicago Press). This new text certainly succeeds as a “toolkit” while in addition providing many detailed well-chosen applications.

In a book of this size one cannot hope to be exhaustive. Rather, a careful choice of topics must be made. In this book you will not find an extensive discussion of black-hole perturbations or a review of the recent advances in dynamical horizons. These topics are well covered elsewhere. Here you will find important topics not well covered elsewhere; for example, a masterful treatment of junction conditions including an original approach to null shells.

The first chapter gives a “brisk” review of the fundamentals of differential geometry. Though indeed it is brisk, it is remarkably clear and supplemented with a dozen very well chosen problems. The bibliographical notes, which continue throughout the entire text chapter by chapter, clearly explain what material the author has relied on. Further, the author makes considered suggestions for further reading. Next follows a rather complete discussion of geodesic congruences, including clear examples that supplement the formalism. A special effort is made to ensure that the reader understands the full meaning of the quantities involved. The problems provide a check to see that the reader has in fact appreciated this essential background material.

Whereas one might argue that the material in the first two chapters could be found elsewhere (though, in my opinion, not as clearly and with such strict attention to pedagogy), the uniqueness of this text comes into focus in Chapter Three. Here one finds an exhaustive, and at times original, treatment of hypersurfaces. After a self-contained discussion of the substantial background mathematics, we are treated to some very instructive examples of non-null shells up to and including the slowly rotating case. These serve to cement the physical importance of the material, material which is presented too briefly elsewhere. The chapter continues into the null case and here presents some new perspectives in an area where we have little intuition.

Chapter Four presents the Lagrangian and Hamiltonian formulation of general relativity. The material moves at a brisk pace but is sufficiently self-contained to be accessible to readers without a strong background in advanced classical mechanics. Again, well-chosen examples clarify the material. For example, the author uses the Vaidya spacetime to drive home the distinction between the ADM and Bondi-Sachs masses.

It is only in the final chapter that we finally meet up with black holes. The diligent reader will be well prepared for this meeting. The discussion begins with a modern global treatment of the Schwarzschild black hole. The distinction between event and apparent horizons is made with a clear example, again using the Vaidya spacetime. A thorough discussion of the Reissner-Nordstrom black hole is used as a background to the Kerr black hole. Here one finds all the standard material, including the laws of black-hole mechanics, discussed with clarity. The chapter ends with a very extensive set of questions.

In summary, *A Relativist’s Toolkit* is an excellent book. It is a model of clarity, reflecting the influence of Werner Israel to whom the book is dedicated. I highly recommend this book to all serious students of general relativity, and consider it necessary reading for those interested in studying black holes.

Kayll Lake,  
Queen’s University, Kingston, Ontario, Canada