Astro. Lett. and Communications, 1998, Vol. 35, pp. 459–460
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Relativity and Scientific Computing: Computer Algebra, Numerics, Visualization

F. W. HEHL, R. A. PUNTIGAM and H. RUDER *(Springer, 1996) 390 pp., hardcover, ISBN: 3-540-60361-1, US $89.95*

This book is a collection of a set of lectures on scientific computing, intended for any student who wants to specialize in relativity and gravitation. It is divided into four main parts: numerics, computer algebra, visualization, and exotica.

The first lecture of the section devoted to numerical methods discusses thoroughly the problem of collisions between black holes. Then, four lectures dealing with the problem of the integration of Einstein's evolution equations follow. Two successive lectures illustrate numerical techniques for numerical relativity and temporal and spatial foliations of spacetimes. The next two lectures of this first section deal with the rotation and oscillation of neutron stars and the rotation of boson stars. Finally, an interesting numerical investigation of the nature of cosmological singularities is presented.

The second part is devoted to the applications of computer algebra to relativity. The first lecture is an extensive review in which various general-purpose and specialized codes are compared. The second lecture deals with the evaluation of two-loops in perturbative quantum gravity, using the program *FORM*. The third and fourth lectures illustrate the main characteristics of the packages *CARTAN* and *MathTensor* (running under *Mathematica*), by deriving the solution for a charged black hole in the Einstein-Maxwell theory, for a spin-polarized cosmic string in the Einstein-Cartan theory, and finally for the gravitational field in the Pawlowski-Raczka Lagrangian formulation. In the fifth lecture the program *CRACK*, developed in order to solve non-linear PDEs, is illustrated, and some examples are discussed. Finally, in lectures six and seven the program *REDUCE* is applied to the derivation of the Hamiltonian theory of GR, and to exterior calculus.

In the third part of the book the problem of visualization is addressed. The first contribution is made up of four lectures on computer graphics and visualization, in which the technologies and mathematics that underlie the present and near-future capabilities of graphics computers are presented. The remaining two lectures discuss the problem of visualization in curved specetimes. In the first, the technique of ray-tracing – applied both to special and general relativity – are discussed. In the second, the visualization of surfaces via embedding is presented, after an introduction of the very basic concepts of differential geometry of surfaces.

The fourth and last section of this book is not dedicated to any numerical or symbolic computation, but to the subject of smoothness on spacetime.

In conclusion, this is a well-written and illustrated book, but due to the technical nature of many lectures, as stated in the preface, the reader is required to have a "reasonable background in physics and general relativity".

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