

Elements of Numerical Relativity and Relativistic Hydrodynamics

From Einstein' s Equations to Astrophysical Simulations

Bearbeitet von
Carles Bona, Carlos Palenzuela-Luque, Carles Bona-Casas

1. Auflage 2011. Taschenbuch. xiv, 214 S. Paperback

ISBN 978 3 642 24250 2

Format (B x L): 15,5 x 23,5 cm

Gewicht: 351 g

[Weitere Fachgebiete > Physik, Astronomie > Physik Allgemein > Theoretische Physik,
Mathematische Physik](#)

Zu [Leseprobe](#)

schnell und portofrei erhältlich bei

The logo for beck-shop.de features the text 'beck-shop.de' in a bold, red, sans-serif font. Above the 'i' in 'shop' are three red dots of increasing size. Below the main text, 'DIE FACHBUCHHANDLUNG' is written in a smaller, red, all-caps, sans-serif font.

beck-shop.de
DIE FACHBUCHHANDLUNG

Die Online-Fachbuchhandlung beck-shop.de ist spezialisiert auf Fachbücher, insbesondere Recht, Steuern und Wirtschaft. Im Sortiment finden Sie alle Medien (Bücher, Zeitschriften, CDs, eBooks, etc.) aller Verlage. Ergänzt wird das Programm durch Services wie Neuerscheinungsdienst oder Zusammenstellungen von Büchern zu Sonderpreisen. Der Shop führt mehr als 8 Millionen Produkte.

Contents

1	The 4D Spacetime	1
1.1	Spacetime geometry	1
1.1.1	The metric	1
1.1.2	General covariance	2
1.1.3	Covariant derivatives	3
1.1.4	Curvature	5
1.1.5	Symmetries of the curvature tensor	6
1.2	General covariant field equations	7
1.2.1	The stress–energy tensor	7
1.2.2	Einstein’s field equations	8
1.2.3	Structure of the field equations	10
1.3	Einstein’s equations solutions	13
1.3.1	Symmetries: Lie derivatives	13
1.3.2	Exact solutions	15
1.3.3	Analytical and numerical approximations	16
1.4	Harmonic formalism	18
1.4.1	The relaxed system	19
1.4.2	Analytical and numerical applications	20
1.4.3	Harmonic coordinates	22
	References	24
2	The Evolution Formalism	25
2.1	Space plus time decomposition	25
2.1.1	A prelude: Maxwell equations	26
2.1.2	Spacetime synchronization	27
2.1.3	The Eulerian observers	30
2.2	Einstein’s equations decomposition	32
2.2.1	The 3+1 form of the field equations	32
2.2.2	3+1 Covariance	33
2.2.3	Generic space coordinates	35
2.3	The evolution system	38

2.3.1	Evolution and constraints	38
2.3.2	Constraints conservation	39
2.3.3	Evolution strategies.....	40
2.4	Gravitational waves degrees of freedom.....	42
2.4.1	Linearized field equations.....	42
2.4.2	Plane-wave analysis.....	43
2.4.3	Gravitational waves and gauge effects	46
	References	47
3	Free Evolution	49
3.1	The free evolution framework	49
3.1.1	The ADM system	49
3.1.2	Extended solution space.....	50
3.1.3	Plane-wave analysis.....	52
3.2	Robust stability test-bed	55
3.2.1	Finite differences	55
3.2.2	Numerical results.....	58
3.3	Pseudo-hyperbolic systems.....	60
3.3.1	Extra dynamical fields	60
3.3.2	The BSSN system	63
3.3.3	Plane-wave analysis.....	65
3.4	Covariant formulations	67
3.4.1	The Z4 formalism	67
3.4.2	The generalized harmonic formalism	69
3.4.3	Constraint-violation control.....	70
3.5	The Z4 evolution system	71
3.5.1	3 + 1 Decomposition	71
3.5.2	Plane-wave analysis.....	73
3.5.3	Symmetry breaking.....	75
	References	77
4	First-Order Hyperbolic Systems	79
4.1	First-order versions of second-order systems.....	79
4.1.1	Introducing extra first-order quantities	79
4.1.2	Ordering ambiguities	81
4.1.3	First-order Z4 system (normal coordinates)	82
4.1.4	Symmetry breaking: the KST system	83
4.2	Hyperbolic systems	86
4.2.1	Weak and strong hyperbolicity	86
4.2.2	1D Energy estimates.....	89
4.2.3	Symmetric-hyperbolic systems	91
4.3	Generic space coordinates	93
4.3.1	First-order fields	93
4.3.2	Generalized harmonic formulations	96
4.3.3	First-order Z4 formalism	98

4.4	Boundary conditions	100
4.4.1	Algebraic boundary conditions	101
4.4.2	Energy methods	103
4.4.3	Robust stability test	106
	References	108
5	Numerical Methods	109
5.1	Finite difference methods	110
5.1.1	Accuracy and stability	110
5.1.2	The method of lines	112
5.1.3	Artificial dissipation	113
5.1.4	The gauge waves test-bed	115
5.2	Finite volume methods	117
5.2.1	Systems of balance laws	118
5.2.2	Weak solutions	120
5.2.3	Flux formulae	123
5.2.4	High-resolution methods	126
5.2.5	The modified flux approach	130
5.3	Simple CFD tests	132
5.3.1	Advection equation	133
5.3.2	Burgers equation	135
5.3.3	Euler equations: Sod test	137
5.3.4	MHD equations: Orszag–Tang vortex	138
	References	141
6	Black Hole Simulations	143
6.1	Black Hole initial data	143
6.1.1	Conformal metric decomposition	146
6.1.2	Singular initial data: punctured black holes	147
6.1.3	Regular initial data	149
6.2	Dynamical time slicing	155
6.2.1	Singularity avoidance	155
6.2.2	Limit surfaces	157
6.2.3	Gauge pathologies	159
6.3	Numerical Black Hole milestones	160
6.3.1	Short-term simulations	160
6.3.2	Long-term simulations	166
6.3.3	Further developments	167
	References	169
7	Matter Spacetimes	171
7.1	Scalar fields	172
7.1.1	The Klein–Gordon equation	172
7.1.2	Boson stars initial data	174
7.1.3	Evolution of a single boson star	178

7.2	Electromagnetic fields	179
7.2.1	Maxwell equations	180
7.2.2	Electromagnetic potential	181
7.2.3	The electromagnetic fields	183
7.2.4	The electromagnetic stress-energy tensor	185
7.3	Hydrodynamics	185
7.3.1	Perfect fluids	186
7.3.2	The equation of state	189
7.3.3	Neutron stars	192
7.4	Magnetohydrodynamics	195
7.4.1	The MHD evolution equations	196
7.4.2	Generalized Ohm's law	197
7.4.3	Ideal MHD	200
7.4.4	The force-free limit	204
7.5	Further developments	205
7.5.1	Boson stars collisions	205
7.5.2	Neutron stars collisions	207
	References	209
	Index	211

Elements of Numerical Relativity and Relativistic
Hydrodynamics

From Einstein' s Equations to Astrophysical Simulations

Bona, C.; Palenzuela-Luque, C.; Bona-Casas, C.

2009, XIV, 214 p. 108 illus., Hardcover

ISBN: 978-3-642-01163-4