

Contents

Part I Two-Time Physics: The Unified View from Higher Dimensional Space and Time

Itzhak Bars

1	A First Look at the Known Universe	7
2	Structure of Matter and Fundamental Forces	13
2.1	The Fundamentals at Subatomic Distances	13
2.2	Large Distances and Cosmology	21
3	What Is Space–Time?	29
3.1	Einstein’s Relativistic View of Space–Time	33
3.2	Equivalence Principle, Symmetry, and General Relativity	38
4	Symmetry and Perspective	43
5	Why Higher Space or Time Dimensions?	47
5.1	Extra Space Dimensions	49
5.2	A Matter of Perspective in 2T Space–time	51
5.3	Why Two Times	54
5.4	The Shadows Allegory	56
6	The Role of Extra Space Dimensions in String Theory	59
7	Two-Time Physics	67
7.1	Historical Path to the $Sp(2, R)$ Symmetry	67
7.2	Indistinguishable Position and Momentum and $Sp(2, R)$	72
7.3	How Does It Work?	75
7.3.1	Informal Discussion	77
7.3.2	Formal Discussion	78
7.4	Examples of Shadows and Hidden Information	81
8	Evidence of $4 + 2$ as Subtle Effects in $3 + 1$ Dimensions	89
8.1	H-Atom	89
8.2	The Fourth Space Dimension in Celestial Mechanics	95

9	Fundamental Universe as a Shadow from 4 + 2 Dimensions	99
9.1	The Standard Model as a 2T-Field Theory	101
9.2	2T-Gravity in 4 + 2 Dimensions	104
9.3	Dilaton-Driven Cosmic Phase Transitions	106
9.4	Electroweak Phase Transition	109
10	Current Status of 2T-Physics and Future Directions	113
11	Further Reading	123
	References	123

Part II Extra Dimensions of Space

John Terning

12	The Popular View of Extra Dimensions	129
12.1	Einstein and the Fourth Dimension	130
12.2	Traditional Extra Dimensions	141
12.3	Einstein's Gravity	146
12.4	The Theory Formerly Known as String	149
12.5	Warped Extra Dimensions	154
12.6	How Do We Look for Extra Dimensions?	158
12.7	Epilogue	165
	References	165
13	Extra Material: The Equations Behind the Words	167
13.1	Units and Coordinates	167
13.2	Einstein and the Fourth Dimension	169
13.3	Quantum Mechanics	178
13.4	Traditional Extra Dimensions	182
13.5	Einstein's Gravity	185
13.6	The Theory Formerly Known as String	190
13.7	Warped Extra Dimensions	197
13.8	The Maxwell Equations	201
13.9	How Do We Look for Extra Dimensions?	208
	About the Authors	211
	Index	213