



## TABLE OF CONTENTS

<b>PREFACE</b>	IX
<b>ACKNOWLEDGEMENTS</b>	XI
<b>HERBERT GURSKY and REMO RUFFINI / Introduction</b>	1
1. Early History	2
2. The Basic Theoretical Works on Gravitational Collapse	4
3. The Discovery of Neutron Stars and Black Holes	6
<b>STIRLING A. COLGATE / Supernovae</b>	13
1. Introduction	13
2. Energetics of Supernovae	14
3. The Origin of Supernovae	17
4. The Mechanisms of Supernovae Explosions	19
5. The Explosion Process and Neutron Star Formation	19
6. Binding Energies	20
7. Neutrinos in Supernovae	22
<b>R. B. PARTRIDGE / Pulse Astronomy: Short Time Scale Phenomena in Electromagnetic and Gravitational Wave Astronomy</b>	29
1. The Death of Stars	30
2. Pulses of Gravitational and Electromagnetic Radiation (and Neutrinos)	32
3. Pulsars	42
4. The UHURU Satellite and Pulsating X-Ray Sources	43
5. Gamma-Ray Bursts	43
6. Conclusions	44
<b>IAN BALFOUR STRONG / Cosmic Gamma-Ray Bursts</b>	47
1. Introduction	47
2. The Discovery of Cosmic Gamma-Ray Bursts	47
3. The Characteristics of Gamma-Ray Bursts	50
4. Proposed Explanations for Gamma-Ray Bursts	56
<b>REMO RUFFINI / The Physics of Gravitationally Collapsed Objects</b>	59
1. Introduction	59
2. Neutron Stars	61
3. Black Holes	68

4. Gravitational Radiation Detectors	78
5. Observations and Criteria to Differentiate Between Neutron Stars and Black Holes	81
6. Regularly Pulsating Binary X-Ray Sources	85
7. Bursting Binary X-Ray Sources	89
8. White Dwarfs in Contact Binary Systems	98
9. The Moment of Gravitational Collapse	103
10. Conclusions	112
 EDWARD J. GROTH / Observational Properties of Pulsars	 119
1. Introduction	119
2. Basic Parameters	119
3. Propagation of the Pulses	120
4. Pulsar-Supernova Remnant Associations	132
5. Pulsar Distances and Distributions	136
6. Pulsar Flux Density Spectra	140
7. Pulses	144
8. Pulse Timing	160
9. Concluding Remarks	166
 HERBERT GURSKY and ETHAN SCHREIER / The Galactic X-Ray Sources	 175
1. Introduction	175
2. General Characteristics of the Galactic X-Ray Sources	177
3. Observations of Specific Galactic X-Ray Sources	185
4. A Standard Model for the X-Ray Sources – Close Binary Systems and Accretion	208
5. Summary	213
6. Appendix: Galactic X-Ray Sources	214
 PAUL E. BOYNTON / Optical Observations of Binary X-Ray Sources	 221
1. HZ Herculis – Hercules X-1	222
2. Cygnus X-1	229
 ROBERT P. KRAFT / Black Holes and Neutron Stars: Evolution of Binary Systems	 235
1. Direct Observational Evidence for the Existence of Black Holes and Neutron Stars	235
2. Origins of the Accretion Hypothesis in X-Ray Binaries	236
3. Accretion onto Neutron Stars and Black Holes	238
4. Some Evolutionary Scenarios for Mass-Transfer Binaries	244
5. Summary	253

## APPENDIX I / CLASSIC PAPERS

S. CHANDRASEKHAR / The Highly Collapsed Configuration of a Stellar Mass	259
L. LANDAU / On the Theory of Stars	271
W. BAADE and F. ZWICKY / Supernovae and Cosmic Rays	282
J. R. OPPENHEIMER and G. M. VOLKOFF / On Massive Neutron Cores	283
J. R. OPPENHEIMER and H. SNYDER / On Continued Gravitational Collapse	296
S. CHANDRASEKHAR / Some Remarks on the State of Matter in the Interior of Stars	274
J. WEBER / Detection and Generation of Gravitational Waves	303

## APPENDIX II / CONTEMPORARY PAPERS LEADING TO THE DISCOVERY OF GRAVITATIONALLY COLLAPSED STARS

R. GIACCONI, H. GURSKY, F. R. PAOLINI, and B. B. ROSSI / Evidence for X-rays from Sources Outside the Solar System	321
Y.A. B. ZEL'DOVICH / The Fate of a Star and the Evolution of Gravitational Energy upon Accretion	329
I. S. SHKLOVSKII / The Nature of the X-Ray Source Sco X-1	333
A. HEWISH, S. J. BELL, J. D. PILKINGTON, P. F. SCOTT, and R. A. COLLINS / Observation of a Rapidly Pulsating Radio Source	344
T. GOLD / Rotating Neutron Stars as the Origin of the Pulsating Radio Sources	354
R. PENROSE / Gravitational Collapse: The Role of General Relativity	357
R. RUFFINI and J. A. WHEELER / Introducing the Black Hole	379
V. F. SHVARTSMAN / Halos around Black Holes	394
N. I. SHAKURA / Disk Model of Gas Accretion on a Relativistic Star in a Close Binary System	406
E. SCHREIER, R. LEVINSON, H. GURSKY, E. KELLOGG, H. TANANBAUM, and R. GIACCONI / Evidence for the Binary Nature of Centaurus X-3 from UHURU X-Ray Observations	417
C. E. RHOADES, JR. and R. RUFFINI / Maximum Mass of a Neutron Star	427
R. A. HULSE and J. H. TAYLOR / Discovery of a Pulsar in a Binary System	433
 EDITOR'S COMMENT ON THE BINARY RADIO PULSAR	 438
 INDEX OF SUBJECTS	 439