

## Contents

**About the Author** *xi*

**Foreword** *xiii*

**Introduction** *xv*

<b>1</b>	<b>The Asymptotic Perturbation Method for Nonlinear Oscillators</b>	<b>1</b>
1.1	Introduction	1
1.2	Nonlinear Dynamical Systems	3
1.3	The Approximate Solution	5
1.4	Comparison with the Results of the Numerical Integration	10
1.5	External Excitation in Resonance with the Oscillator	11
1.6	Conclusion	16
<b>2</b>	<b>The Asymptotic Perturbation Method for Remarkable Nonlinear Systems</b>	<b>19</b>
2.1	Introduction	19
2.2	Periodic Solutions and Their Stability	21
2.3	Global Analysis of the Model System	27
2.4	Infinite-period Symmetric Homoclinic Bifurcation	35
2.5	A Few Considerations	41
2.6	A Peculiar Quasiperiodic Attractor	42
2.7	Building an Approximate Solution	44
2.8	Results from Numerical Simulation	46
2.9	Conclusion	52
<b>3</b>	<b>The Asymptotic Perturbation Method for Vibration Control with Time-delay State Feedback</b>	<b>53</b>
3.1	Introduction	53
3.2	Time-delay State Feedback	53
3.3	The Perturbation Method	56
3.4	Stability Analysis and Parametric Resonance Control	59
3.4.1	The Frequency-Response Curve Is	62

3.5	Suppression of the Two-period Quasiperiodic Motion	63
3.6	Vibration Control for Other Nonlinear Systems	68
<b>4</b>	<b>The Asymptotic Perturbation Method for Vibration Control by Nonlocal Dynamics</b>	<b>69</b>
4.1	Introduction	69
4.2	Vibration Control for the van der Pol Equation	72
4.3	Stability Analysis and Parametric Resonance Control	74
4.4	Suppression of the Two-period Quasiperiodic Motion	79
4.5	Conclusion	82
<b>5</b>	<b>The Asymptotic Perturbation Method for Nonlinear Continuous Systems</b>	<b>83</b>
5.1	Introduction	83
5.2	The Approximate Solution for the Primary Resonance of the $n$ th Mode	86
5.3	The Approximate Solution for the Subharmonic Resonance of Order One-half of the $n$ th Mode	91
5.4	Conclusion	93
<b>6</b>	<b>The Asymptotic Perturbation Method for Dispersive Nonlinear Partial Differential Equations</b>	<b>95</b>
6.1	Introduction	95
6.2	Model Nonlinear PDES Obtained from the Kadomtsev–Petviashvili Equation	97
6.3	The Lax Pair for the Model Nonlinear PDE	98
6.4	A Few Remarks	100
6.5	A Generalized Hirota Equation in $2 + 1$ Dimensions	100
6.6	Model Nonlinear PDEs Obtained from the KP Equation	101
6.7	The Lax Pair for the Hirota–Maccari Equation	103
6.8	Conclusion	105
<b>7</b>	<b>The Asymptotic Perturbation Method for Physics Problems</b>	<b>107</b>
7.1	Introduction	107
7.2	Derivation of the Model System	108
7.3	Integrability of the Model System of Equations	111
7.4	Exact Solutions for the C-integrable Model Equation	112
7.4.1	Nonlinear Wave	112
7.4.2	Solitons	112
7.4.3	Dromions	113
7.4.4	Lumps	116
7.4.5	Ring Solitons	116
7.4.6	Instantons	117

- 7.4.7 Moving Breather-Like Structures 117
- 7.5 Conclusion 120

## **8 The Asymptotic Perturbation Model for Elementary Particle Physics 121**

- 8.1 Introduction 121
- 8.2 Derivation of the Model System 122
- 8.3 Integrability of the Model System of Equations 124
- 8.4 Exact Solutions for the  $C$ -integrable Model Equation 125
  - 8.4.1 Nonlinear Wave 125
  - 8.4.2 Solitons 126
  - 8.4.3 Dromions 126
  - 8.4.4 Lumps 127
  - 8.4.5 Ring Solitons 127
  - 8.4.6 Instantons 129
  - 8.4.7 Moving Breather-like Structures 129
- 8.5 A Few Considerations 130
- 8.6 Hidden Symmetry Models 130
- 8.7 Derivation of the Model System 133
- 8.8 Coherent Solutions 138
  - 8.8.1 Nonlinear Wave 138
  - 8.8.2 Solitons 138
  - 8.8.3 Dromions 139
  - 8.8.4 Lumps 139
  - 8.8.5 Ring Solitons 140
  - 8.8.6 Instantons 141
  - 8.8.7 Moving Breather-like Structures 142
- 8.9 Chaotic and Fractal Solutions 143
  - 8.9.1 Chaotic-Chaotic and Chaotic-Periodic Patterns 143
  - 8.9.2 Chaotic Line Soliton Solutions 145
  - 8.9.3 Chaotic Dromion and Lump Patterns 145
  - 8.9.4 Nonlocal Fractal Solutions 147
  - 8.9.5 Fractal Dromion and Lump Solutions 147
  - 8.9.6 Stochastic Fractal Dromion and Lump Excitations 148
- 8.10 Conclusion 150

## **9 The Asymptotic Perturbation Method for Rogue Waves 151**

- 9.1 Introduction 151
- 9.2 The Mathematical Framework 153
- 9.3 The Maccari System 154
- 9.4 Rogue Wave Physical Explanation According to the Maccari System and Blowing Solutions 156
- 9.5 Conclusion 158

<b>10</b>	<b>The Asymptotic Perturbation Method for Fractal and Chaotic Solutions</b>	<b>159</b>
10.1	Introduction	159
10.2	A New Integrable System from the Dispersive Long-wave Equation	161
10.3	Nonlinear Coherent Solutions	165
10.3.1	Nonlinear Wave	165
10.3.2	Solitons	165
10.3.3	Dromions	166
10.3.4	Lumps	166
10.3.5	Ring Solitons	167
10.3.6	Instantons	167
10.3.7	Moving Breather-Like Structures	168
10.4	Chaotic and Fractal Solutions	168
10.4.1	Chaotic–Chaotic and Chaotic–Periodic Patterns	168
10.4.2	Chaotic Line Soliton Solutions	168
10.4.3	Chaotic Dromion and Lump Patterns	169
10.4.4	Nonlocal Fractal Solutions	169
10.4.5	Fractal Dromion and Lump Solutions	169
10.4.6	Stochastic Fractal Excitations	170
10.4.7	Stochastic Fractal Dromion and Lump Excitations	170
10.5	Conclusion	171
<b>11</b>	<b>The Asymptotic Perturbation Method for Nonlinear Relativistic and Quantum Physics</b>	<b>173</b>
11.1	Introduction	173
11.2	The NLS Equation for $a_1 > 0$	174
11.3	The NLS Equation for $a_1 < 0$	176
11.4	A Possible Extension	178
11.5	The Nonrelativistic Case	180
11.6	The Relativistic Case	183
11.7	Conclusion	185
<b>12</b>	<b>Cosmology</b>	<b>187</b>
12.1	Introduction	187
12.2	A New Field Equation	188
12.3	Exact Solution in the Robertson–Walker Metrics	191
12.4	Entropy Production	195
12.5	Conclusion	197
<b>13</b>	<b>Confinement and Asymptotic Freedom in a Purely Geometric Framework</b>	<b>199</b>
13.1	Introduction	199
13.2	The Uncertainty Principle	201
13.3	Confinement and Asymptotic Freedom for the Strong Interaction	203

- 13.4      The Motion of a Light Ray Into a Hadron    207
- 13.5      Conclusion    208
  
- 14        The Asymptotic Perturbation Method for a Reverse  
          Infinite-Period Bifurcation in the Nonlinear Schrodinger  
          Equation    209**
- 14.1      Introduction    209
- 14.2      Building an Approximate Solution    210
- 14.3      A Reverse Infinite-Period Bifurcation    212
- 14.4      Conclusion    215
  
- Conclusion    217**
- References    219**
- Index    235**