Contents

Preface ix

1 Bifurcation and degenerate decomposition in multiple time scale dynamical systems 1
John Guckenheimer
1.1 Definitions and background 4
1.2 Slow-fast decompositions 8
1.3 Degenerate decomposition and bifurcation 10
1.4 The forced Van der Pol equation 13
Acknowledgment 18
References 19

2 Many-body quantum mechanics 21
Robert S MacKay
2.1 Signs of nonlinearity in quantum mechanics 24
2.2 Discrete breathers 27
2.3 Experimental evidence for quantum discrete breathers 33
2.4 Towards a mathematical theory of quantum discrete breathers 35
2.5 Obstructions to the theory 39
2.6 A proposed solution 41
2.7 A tentative application to 4-methyl pyridine 47
2.8 Conclusion 51
Acknowledgments 52
References 52

3 Unfolding complexity: hereditary dynamical systems—new bifurcation schemes and high dimensional chaos 55
Uwe an der Heiden
3.1 Hereditary systems 55
3.2 Difference equations with continuous argument: idealized turbulence 60
3.3 First-order difference-differential equations: a singular perturbation problem with bifurcation gaps 61
3.4 Prime number dynamics of a retarded difference equation 64
## Contents

3.5 Second-order non-smooth difference-differential equations 67  
3.6 Outlook 70  
  Acknowledgment 70  
  References 70

4 Creating stability out of instability 73  
**Christopher K R T Jones**  
4.1 Nonlinear optical fibres 74  
4.2 Can two unstable waves make a stable pulse? 84  
4.3 Some predictions, suggestions and questions 88  
  References 89

5 Signal or noise? A nonlinear dynamics approach to spatio-temporal communication 91  
**Gregory D Van Wiggeren, Jordi Garcia-Ojalvo and Rajarshi Roy**  
5.1 Communication with dynamically fluctuating states of light polarization 94  
5.2 Spatio-temporal communication with synchronized optical chaos 105  
5.3 Conclusions 112  
  Acknowledgments 113  
  References 113

6 Outstanding problems in the theory of pattern formation 117  
**Edgar Knobloch**  
6.1 Pattern selection on lattices 128  
6.2 Imperfection sensitivity 132  
6.3 Coupled Ginzburg–Landau equations 138  
6.4 The nearly-inviscid Faraday System 141  
6.5 Nonlinear waves in extended systems with broken reflection symmetry 149  
6.6 Summary and conclusions 158  
  Acknowledgments 159  
  References 159

7 Is chaos relevant to fluid mechanics? 167  
**Tom Mullin**  
7.1 Taylor–Couette flow 167  
7.2 Preliminary observations 170  
7.3 Symmetry considerations 173  
7.4 Codimension-two bifurcations 174  
7.5 Imperfect gluing bifurcations 180  
7.6 Conclusion 182  
  Acknowledgments 183  
  References 184
### 8 Time-reversed acoustics and chaos

**Mathias Fink**

- 8.1 Time-reversal mirrors 188
- 8.2 Time-reversal experiments 192
- 8.3 Time reversal in chaotic cavities 198
- 8.4 Conclusion 206
  - Acknowledgments 206
  - References 206

### 9 Reduction methods applied to non-locally coupled oscillator systems

**Yoshiki Kuramoto**

- 9.1 When coupling non-locality becomes crucial 211
- 9.2 Rotating spiral waves without phase singularity 213
- 9.3 Simpler case: coexistence of coherent and incoherent domains 218
- 9.4 Concluding remarks 224
  - References 225

### 10 A prime number of prime questions about vortex dynamics in nonlinear media

**Art Winfree**

- 10.1 Stable organizing centres 230
- 10.2 Persistent organizing centres 248
- 10.3 Igniting resistance to curvature-induced contraction 251
- 10.4 Dynamic C: synchronization 258
- 10.5 Ball-park estimation of pertinent quantities 260
- 10.6 Passing in silence from 1994 to 2002 262
  - Acknowledgments 264
  - Addendum while in press 264
  - References 264

### 11 Spontaneous pattern formation in primary visual cortex

**Paul C Bressloff and Jack D Cowan**

- 11.1 The Turing mechanism and its role in cooperative cortical dynamics 274
- 11.2 A continuum model of V1 and its intrinsic circuitry 281
- 11.3 Orientation tuning and O(2) symmetry 285
- 11.4 Amplitude equation for interacting hypercolumns 288
- 11.5 Cortical pattern formation and E(2) symmetry 292
- 11.6 Spatial frequency tuning and SO(3) symmetry 307
- 11.7 Future directions 316
  - References 317
## Contents

12 Models for pattern formation in development

*Bard Ermentrout and Remus Osan*

12.1 Competition

12.2 Spatial scales

12.3 Orientation maps and feature maps

12.4 Kohonen maps and abstract feature models

12.5 Conclusions

References

13 Spatio-temporal nonlinear dynamics: a new beginning

*William L. Ditto*

13.1 Fibrillation of the heart

13.2 Neuro computing

13.3 Where do we go from here?

Acknowledgments

References

**Author index**