

# New Directions in Statistical Physics

Econophysics, Bioinformatics, and Pattern Recognition

Bearbeitet von  
Luc T Wille

1. Auflage 2004. Buch. xviii, 363 S. Hardcover

ISBN 978 3 540 43182 4

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

Gewicht: 806 g

Weitere Fachgebiete > Physik, Astronomie > Angewandte Physik > Soziophysik,  
Wirtschaftsphysik

schnell und portofrei erhältlich bei

  
DIE FACHBUCHHANDLUNG

Die Online-Fachbuchhandlung beack-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

---

## Part I Fundamental Aspects

---

### **Predicting the Direction of a Time Series**

|                                      |    |
|--------------------------------------|----|
| Dimitrios D. Thomakos .....          | 3  |
| 1 Introduction .....                 | 3  |
| 2 Embedding in Direction Space ..... | 4  |
| 3 Predicting the Direction .....     | 7  |
| 4 Empirical Examples .....           | 11 |
| 5 Concluding Remarks .....           | 14 |
| References .....                     | 14 |

### **On the Variability of Timing in a Spatially Continuous System with Heterogeneous Connectivity**

|                                                                                 |    |
|---------------------------------------------------------------------------------|----|
| Viktor K. Jirsa .....                                                           | 17 |
| 1 Introduction .....                                                            | 17 |
| 2 Spatiotemporal Dynamics and Integral Equations .....                          | 18 |
| 3 Influence of Connectivity: A Two-Point Connection .....                       | 21 |
| 4 Variability of the Timing of Distant Sites .....                              | 23 |
| 4.1 Homogeneous Connectivity Only .....                                         | 25 |
| 4.2 Homogeneous Connectivity and Projection from $A$ to $B$ .....               | 26 |
| 4.3 Homogeneous Connectivity and Bilateral Pathway<br>Between $A$ and $B$ ..... | 26 |
| 4.4 Heterogeneous Pathways Only .....                                           | 27 |
| 5 Conclusions .....                                                             | 28 |
| References .....                                                                | 29 |

### **First Passage Time Problem: A Fokker-Planck Approach**

|                                                           |    |
|-----------------------------------------------------------|----|
| Mingzhou Ding and Govindan Rangarajan .....               | 31 |
| 1 Introduction .....                                      | 31 |
| 2 FPT Distribution for Brownian Motion .....              | 32 |
| 3 FTP Distribution for Continuous Time Random Walks ..... | 38 |
| 4 Summary .....                                           | 45 |
| References .....                                          | 45 |

**First- and Last-Passage Algorithms in Diffusion Monte Carlo**

|                                                              |    |
|--------------------------------------------------------------|----|
| James A. Given, Chi-Ok Hwang, and Michael Mascagni . . . . . | 47 |
| 1 Introduction . . . . .                                     | 47 |
| 2 The Angle-Averaging Method . . . . .                       | 52 |
| 3 The Simulation-Tabulation (ST) Method . . . . .            | 53 |
| 4 The Feynman-Kac Method . . . . .                           | 56 |
| 5 Last Passage Methods for Diffusion Monte Carlo . . . . .   | 58 |
| 6 Conclusions and Suggestions for Further Study . . . . .    | 64 |
| References . . . . .                                         | 65 |

**Part II Econophysics**

**An Updated Review of the LLS Stock Market Model:  
Complex Market Ecology, Power Laws  
in Wealth Distribution and Market Returns**

|                                                                         |    |
|-------------------------------------------------------------------------|----|
| Sorin Solomon and Moshe Levy . . . . .                                  | 69 |
| 1 Introduction to the Levy-Levy-Solomon (LLS) Model . . . . .           | 69 |
| 2 Crashes, Booms and Cycles . . . . .                                   | 71 |
| 3 Predation, Competition and Symbiosis Between Trader Species . . . . . | 73 |
| 3.1 Market Ecologies with Two Trader Species . . . . .                  | 73 |
| 3.2 Three Investor Species . . . . .                                    | 79 |
| 4 LLS with Many Species: Realistic Dynamics of Market Returns . . . . . | 80 |
| 4.1 Return Autocorrelations: Momentum and Mean-Reversion . . . . .      | 80 |
| 4.2 Excess Volatility . . . . .                                         | 81 |
| 4.3 Heavy Trading Volume . . . . .                                      | 81 |
| 4.4 Volume is Positively Correlated with Absolute Returns . . . . .     | 81 |
| 5 The Emergence of Pareto's Law in LLS . . . . .                        | 82 |
| 6 Market Efficiency, Pareto Law and Thermal Equilibrium . . . . .       | 84 |
| 7 Leptokurtic Market Returns in LLS . . . . .                           | 86 |
| 8 Summary . . . . .                                                     | 89 |
| References . . . . .                                                    | 89 |

**Patterns, Trends and Predictions in Stock Market Indices  
and Foreign Currency Exchange Rates**

|                                                                      |     |
|----------------------------------------------------------------------|-----|
| Marcel Ausloos and Kristinka Ivanova . . . . .                       | 93  |
| 1 An Introduction with Some Historical Notes as "Symptoms" . . . . . | 93  |
| 1.1 Tulipomania . . . . .                                            | 95  |
| 1.2 Monopolymania . . . . .                                          | 96  |
| 1.3 WallStreetmania . . . . .                                        | 97  |
| 2 Econophysics of Stock Market Indices . . . . .                     | 98  |
| 2.1 Methodology and Data Analysis . . . . .                          | 101 |
| 2.2 Aftershock Patterns . . . . .                                    | 104 |
| 3 Foreign Currency Exchange Rates . . . . .                          | 107 |

|     |                                      |     |
|-----|--------------------------------------|-----|
| 3.1 | DFA Analysis .....                   | 107 |
| 3.2 | Data and Analysis .....              | 108 |
| 3.3 | Probing the Local Correlations ..... | 110 |
| 4   | Conclusions .....                    | 112 |
|     | References .....                     | 112 |

## **Toward an Understanding of Financial Markets**

### **Using Multi-agent Games**

Neil F. Johnson, David Lamper, Paul Jefferies, and Michael L. Hart ... 115

|   |                                            |     |
|---|--------------------------------------------|-----|
| 1 | Introduction .....                         | 115 |
| 2 | The Basic MG .....                         | 115 |
| 3 | Grand Canonical Minority Game .....        | 119 |
| 4 | Next Timestep Prediction .....             | 121 |
| 5 | Corridors for Future Price Movements ..... | 123 |
| 6 | Real-World Risk .....                      | 124 |
| 7 | Conclusion .....                           | 126 |
|   | References .....                           | 127 |

## **Towards Understanding the Predictability of Stock Markets from the Perspective of Computational Complexity**

James Aspnes, David F. Fischer, Michael J. Fischer,

Ming-Yang Kao, and Alok Kumar ..... 129

|   |                                                                                  |     |
|---|----------------------------------------------------------------------------------|-----|
| 1 | Introduction .....                                                               | 129 |
| 2 | A Basic Market Model .....                                                       | 130 |
|   | 2.1 Defining the DSMC Model .....                                                | 131 |
|   | 2.2 Computer Simulation on the DSMC Model .....                                  | 133 |
| 3 | A General Market Model .....                                                     | 134 |
| 4 | Predicting the Market .....                                                      | 135 |
|   | 4.1 Markets as Systems of Linear Constraints .....                               | 136 |
|   | 4.2 An Easy Case for Market Prediction:<br>Many Traders but Few Strategies ..... | 138 |
|   | 4.3 A Hard Case for Market Prediction: Many Strategies .....                     | 141 |
| 5 | Future Research Directions .....                                                 | 149 |
|   | References .....                                                                 | 150 |

## **Patterns in Economic Phenomena**

H. E. Stanley, P. Gopikrishnan, V. Plerou, and M. A. Salinger ..... 153

|   |                                                                    |     |
|---|--------------------------------------------------------------------|-----|
| 1 | Introduction to Patterns in Economics .....                        | 153 |
| 2 | Classic Approaches to Finance Patterns .....                       | 156 |
| 3 | Patterns in Finance Fluctuations .....                             | 157 |
| 4 | Patterns Resembling “Diffusion in a Tsunami Wave” .....            | 161 |
| 5 | Patterns Resembling Critical Point Phenomena .....                 | 162 |
| 6 | Cross-Correlations in Price Fluctuations of Different Stocks ..... | 164 |
| 7 | Patterns in Firm Growth .....                                      | 164 |

|   |                                               |     |
|---|-----------------------------------------------|-----|
| 8 | Universality of the Firm Growth Problem ..... | 165 |
| 9 | “Take-Home Message” .....                     | 166 |
|   | References .....                              | 167 |

---

## Part III Bioinformatics

---

### New Algorithms and the Physics of Protein Folding

|   |                                                  |     |
|---|--------------------------------------------------|-----|
|   | Ulrich H.E. Hansmann .....                       | 173 |
| 1 | Introduction .....                               | 173 |
| 2 | The Generalized-Ensemble Approach .....          | 175 |
|   | 2.1 Multicanonical Sampling .....                | 175 |
|   | 2.2 $1/k$ -Sampling .....                        | 177 |
|   | 2.3 Simulated Tempering .....                    | 178 |
|   | 2.4 Other Generalized Ensembles .....            | 178 |
|   | 2.5 Parallel Tempering .....                     | 179 |
| 3 | The Thermodynamics of Folding .....              | 180 |
|   | 3.1 Helix-Coil Transitions in Homopolymers ..... | 180 |
|   | 3.2 Energy Landscape Analysis of Peptides .....  | 185 |
| 4 | Structure Prediction of Proteins .....           | 188 |
| 5 | Conclusion .....                                 | 190 |
|   | References .....                                 | 190 |

### Sequence Alignment in Bioinformatics

|   |                                           |     |
|---|-------------------------------------------|-----|
|   | Yi-Kuo Yu .....                           | 193 |
| 1 | Introduction to Sequence Alignment .....  | 193 |
|   | 1.1 The Holy Grail .....                  | 194 |
|   | 1.2 Alignment Algorithms .....            | 195 |
|   | 1.3 Score Statistics .....                | 200 |
|   | 1.4 Substitution (Scoring) Matrices ..... | 201 |
| 2 | Some Recent Developments .....            | 204 |
|   | 2.1 Optimal Alignments .....              | 204 |
|   | 2.2 Hybrid Alignment .....                | 205 |
|   | 2.3 Open Problems .....                   | 208 |
|   | References .....                          | 211 |

### Resolution of Some Paradoxes

#### in B-Cell Binding and Activation: A Computer Study

|   |                                                                                   |     |
|---|-----------------------------------------------------------------------------------|-----|
|   | Gyan Bhanot .....                                                                 | 213 |
| 1 | Introduction .....                                                                | 213 |
| 2 | Brief Description of Human Immune System .....                                    | 214 |
| 3 | The Dintzis Experimental Results and the Immunon Theory .....                     | 217 |
| 4 | Modeling the B-Cell Receptor Binding to Antigen:<br>Our Computer Experiment ..... | 217 |

|   |                  |     |
|---|------------------|-----|
| 5 | Results .....    | 219 |
|   | References ..... | 224 |

## **Proliferation and Competition in Discrete Biological Systems**

|   |                                                             |     |
|---|-------------------------------------------------------------|-----|
|   | Yoram Louzoun and Sorin Solomon .....                       | 225 |
| 1 | Introduction .....                                          | 225 |
| 2 | Dynamics of Discrete Proliferating Agents .....             | 227 |
| 3 | How Well Do Different Methods Deal with Discreteness? ..... | 229 |
| 4 | Single $S$ Analysis .....                                   | 230 |
| 5 | RG Analysis .....                                           | 232 |
| 6 | Mechanisms Limiting Population Growth .....                 | 233 |
|   | 6.1 Local Competition .....                                 | 234 |
|   | 6.2 Global Competition .....                                | 235 |
|   | 6.3 Emergence of Complexity .....                           | 238 |
| 7 | Discussion .....                                            | 239 |
|   | 7.1 Dimensionality .....                                    | 240 |
|   | 7.2 Inter-Scale Information Flow .....                      | 240 |
|   | References .....                                            | 241 |

## **Privacy and Data Exchanges**

|   |                                                      |     |
|---|------------------------------------------------------|-----|
|   | Bernardo A. Huberman .....                           | 243 |
| 1 | Introduction .....                                   | 243 |
| 2 | A Lightning Review of Cryptographic Techniques ..... | 245 |
| 3 | Secret Matching of Data Sets .....                   | 246 |
| 4 | Private Surveys in the Public Arena .....            | 247 |
| 5 | Conclusion .....                                     | 250 |
|   | References .....                                     | 250 |

---

## **Part IV Pattern Recognition**

---

### **Statistical Physics and the Clustering Problem**

|   |                                                                                   |     |
|---|-----------------------------------------------------------------------------------|-----|
|   | Sebastiano Stramaglia, Carmela Marangi,<br>Luigi Nitti, and Mario Pellicoro ..... | 253 |
| 1 | Introduction .....                                                                | 253 |
| 2 | Hierarchical Clustering for Phylogeny Reconstruction .....                        | 255 |
|   | 2.1 Coupled Map Clustering (CMC) Algorithm .....                                  | 255 |
|   | 2.2 Distance Measures .....                                                       | 257 |
|   | 2.3 Experiment .....                                                              | 259 |
|   | 2.4 Discussion .....                                                              | 260 |
| 3 | The Auto-encoder Frame .....                                                      | 261 |
|   | 3.1 Cost Functions .....                                                          | 261 |
|   | 3.2 Deterministic Annealing .....                                                 | 264 |
|   | 3.3 Experiments .....                                                             | 264 |

|     |                                                                                    |     |
|-----|------------------------------------------------------------------------------------|-----|
| 3.4 | Resampling Technique for Unsupervised Estimation<br>of the Number of Classes ..... | 266 |
| 3.5 | Discussion .....                                                                   | 268 |
| 4   | Conclusions .....                                                                  | 271 |
|     | References .....                                                                   | 271 |

### **The Challenges of Clustering High Dimensional Data**

|      |                                                                               |     |
|------|-------------------------------------------------------------------------------|-----|
|      | Michael Steinbach, Levent Ertöz, and Vipin Kumar .....                        | 273 |
| 1    | Introduction .....                                                            | 273 |
| 2    | Basic Concepts and Techniques of Cluster Analysis .....                       | 274 |
| 2.1  | What Cluster Analysis Is .....                                                | 274 |
| 2.2  | What Cluster Analysis Is Not .....                                            | 275 |
| 2.3  | The Data Matrix .....                                                         | 275 |
| 2.4  | The Proximity Matrix .....                                                    | 276 |
| 2.5  | The Proximity Graph .....                                                     | 276 |
| 2.6  | Some Working Definitions of a Cluster .....                                   | 276 |
| 2.7  | Measures (Indices) of Similarity and Dissimilarity .....                      | 279 |
| 2.8  | Hierarchical and Partitional Clustering .....                                 | 281 |
| 2.9  | Specific Partitional Clustering Techniques: K-Means .....                     | 282 |
| 2.10 | Specific Hierarchical Clustering Techniques:<br>MIN, MAX, Group Average ..... | 283 |
| 3    | The “Curse of Dimensionality” .....                                           | 284 |
| 4    | Recent Work in Clustering High Dimensional Data .....                         | 288 |
| 4.1  | Clustering via Hypergraph Partitioning .....                                  | 288 |
| 4.2  | Grid Based Clustering Approaches .....                                        | 289 |
| 4.3  | Noise Modeling in Wavelet Space .....                                         | 296 |
| 4.4  | A “Concept-Based” Approach<br>to Clustering High Dimensional Data .....       | 297 |
| 5    | Conclusions .....                                                             | 307 |
|      | References .....                                                              | 307 |

---

## **Part V Other Applications**

---

### **Some Statistical Physics Approaches**

#### **for Trends and Predictions in Meteorology**

|     |                                                                                                   |     |
|-----|---------------------------------------------------------------------------------------------------|-----|
|     | Kristinka Ivanova, Marcel Ausloos, Thomas Ackerman,<br>Hampton Shirer, and Eugene Clothiaux ..... | 313 |
| 1   | Introduction .....                                                                                | 313 |
| 1.1 | Techniques of Time Series Analysis .....                                                          | 315 |
| 2   | Experimental Techniques and Data Acquisition .....                                                | 315 |
| 3   | Nonstationarity and Spectral Density .....                                                        | 317 |
| 4   | Roughness and Detrended Fluctuation Analysis .....                                                | 319 |
| 5   | Time Dependence of the Correlations .....                                                         | 322 |

|   |                                        |     |
|---|----------------------------------------|-----|
| 6 | Multi-affinity and Intermittency ..... | 324 |
| 7 | Conclusions .....                      | 326 |
|   | Appendix .....                         | 327 |
|   | References .....                       | 328 |

## **An Initial Look**

### **at Acceleration-Modulated Thermal Convection**

Jeffrey L. Rogers, Michael F. Schatz, Werner Pesch,  
and Oliver Brausch .....

331

|     |                                                        |     |
|-----|--------------------------------------------------------|-----|
| 1   | Introduction .....                                     | 331 |
| 2   | Laboratory .....                                       | 334 |
| 2.1 | Experimental Apparatus .....                           | 334 |
| 2.2 | Numerical Methods .....                                | 336 |
| 3   | Onset, Time-Dependence, and Typical Patterns .....     | 337 |
| 3.1 | Onset Measurements .....                               | 337 |
| 3.2 | Confirmation of Time-Dependence .....                  | 338 |
| 3.3 | Harmonic Patterns at Onset .....                       | 339 |
| 3.4 | Harmonic Patterns away from Onset .....                | 340 |
| 3.5 | Subharmonic Patterns at Onset .....                    | 343 |
| 3.6 | Subharmonic Patterns away from Onset .....             | 343 |
| 4   | Direct Harmonic-Subharmonic Transition .....           | 344 |
| 4.1 | Transition from Pure Harmonics to Coexistence .....    | 345 |
| 4.2 | Transition from Pure Subharmonics to Coexistence ..... | 347 |
| 5   | Superlattices .....                                    | 349 |
| 5.1 | Observations near Bicriticality .....                  | 349 |
| 5.2 | Observations away from Bicriticality .....             | 351 |
| 5.3 | Resonant Tetrads .....                                 | 352 |
| 5.4 | Other Frequencies .....                                | 354 |
| 6   | Discussion .....                                       | 356 |
|     | References .....                                       | 356 |

|                    |     |
|--------------------|-----|
| <b>Index</b> ..... | 359 |
|--------------------|-----|