Contents

Part I Modes of Approximation

1 Contributions of Rabi Bhattacharya to the Central Limit Theory and Normal Approximation
   Peter Hall
   1.1 Rates of Convergence in the Central Limit Theorem .......................... 3
   1.2 Asymptotic Expansions ..................................................... 5
   1.3 Influence on Statistics ...................................................... 6
   1.4 Past, Present, and Future ................................................... 8
   References ............................................................................. 10

2 Asymptotic Expansions for Stochastic Processes
   Nakahiro Yoshida
   2.1 Introduction ............................................................................ 15
   2.2 Refinements of Central Limit Theorems ...................................... 16
      2.2.1 Rate of Convergence of the Central Limit Theorem .................. 16
      2.2.2 Cramér-Edgeworth Expansion .............................................. 17
      2.2.3 Smoothing Inequality ....................................................... 18
      2.2.4 Applications to Statistics .................................................... 19
   2.3 Asymptotic Expansion for Mixing Processes ................................. 19
   2.4 Asymptotic Expansion for Martingales ........................................... 21
      2.4.1 Martingale Central Limit Theorems ....................................... 21
      2.4.2 Berry-Esseen Bounds ...................................................... 22
      2.4.3 Asymptotic Expansion of Martingales ................................... 23
   2.5 Non-ergodic Statistics and Asymptotic Expansion........................... 24
      2.5.1 Non-central Limit of Estimators in Non-ergodic Statistics ........... 24
      2.5.2 Non-ergodic Statistics and Martingale Expansion ..................... 25
   References ............................................................................. 26

3 An Introduction to Normal Approximation
   Qi-Man Shao
   3.1 Introduction ............................................................................. 33
   3.2 Asymptotic Expansions ............................................................. 33
   3.3 Normal Approximation by Stein’s Method ..................................... 36
   3.4 Strong Gaussian Approximation ............................................... 37
   References ............................................................................. 39
4 Reprints: Part I .................................................. 41
   R.N. Bhattacharya and Coauthors
   4.1 “Berry-Essen bounds for the multi-dimensional central
       limit theorem” ............................................ 42
   4.2 “Rates of weak convergence and asymptotic expansions
       for classical central limit theorems” .................... 46
   4.3 “On errors of normal approximation” ....................... 66
   4.4 “Refinements of the multidimensional central limit theorem
       and applications” ........................................... 81
   4.5 “On the validity of the formal Edgeworth expansion” .... 109

Part II Large Time Asymptotics for Markov Processes I: Diffusion

5 Martingale Methods for the Central Limit Theorem .......... 131
   S.R. Srinisava Varadhan
   5.1 Introduction .............................................. 131
   5.2 Methods for Proving the CLT ............................ 131
   5.3 A Bit of History ........................................... 134
   References ..................................................... 135

6 Ergodicity and Central Limit Theorems for Markov Processes .... 137
   Thomas G. Kurtz
   6.1 Introduction .............................................. 137
   6.2 Ergodicity for Markov Processes .......................... 140
       6.2.1 Harris Recurrence ................................. 145
       6.2.2 Conditions without Harris Recurrence .......... 148
   6.3 Central Limit Theorems ................................. 149
   References ..................................................... 153

7 Reprints: Part II .................................................. 155
   R.N. Bhattacharya and Coauthors
   7.1 “Criteria for recurrence and existence of invariant measures
       for multidimensional diffusions” ......................... 156
   7.2 “On the functional central limit theorem and the law of the
       iterated logarithm for Markov processes” ............... 170
   7.3 “A central limit theorem for diffusions with periodic coefficients” 188
   7.4 “Refinements of the multidimensional central limit theorem
       and applications” ........................................... 201
   7.5 “Stability in distribution for a class of singular diffusions” ...... 219
   7.6 “Speed of convergence to equilibrium and to normality
       for diffusions with multiple periodic scales” .......... 230

Part III Large Time Asymptotics for Markov
Processes II: Dynamical Systems and Iterated Maps

8 Dynamical Systems, IID Random Iterations, and Markov Chains .... 265
   Krishna B. Athreya
   8.1 Dynamical Systems ........................................ 265
   8.2 IID Random Iterations ..................................... 267
       8.2.1 Examples ............................................. 267
       8.2.2 A Basic Convergence Theorem .................... 269
### 8.3 Markov Chains

References ................................. 274

### 9 Random Dynamical Systems and Selected Works of Rabi Bhattacharya

Edward C. Waymire

9.1 Introduction and Preliminaries ....................... 277
9.2 A Splitting Theorem ............................... 280
9.3 Related Results and Applications ...................... 281
9.4 Fluctuation Laws and Limit Theorems .................... 283
9.5 Other Approaches, Problems, and Directions .......... 284
9.6 Concluding Remarks ................................ 286

References ..................................... 286

### 10 Reprints: Part III

R.N. Bhattacharya and Coauthors

10.1 “Asymptotics of a class of Markov processes which are not in general irreducible”.............. 290
10.2 “Random iterations of two quadratic maps” ......... 306
10.3 “On a theorem of Dubins and Freedman” ............... 317
10.4 “An approach to the existence of unique invariant probabilities for Markov processes” .......... 339

### Part IV Stochastic Foundations in Applied Sciences I: Economics

11 Stability Analysis for Random Dynamical Systems in Economics .... 363

Takashi Kamihigashi and John Stachurski

11.1 Introduction ..................................... 363
11.2 Basic Economic Models ................................ 365
11.2.1 Optimal Growth .................................. 366
11.2.2 Stability Arguments ............................... 366
11.2.3 Overlapping Generations ......................... 367
11.2.4 Other Applications .............................. 368
11.3 Stability Conditions .................................. 368
11.3.1 Splitting ......................................... 368
11.3.2 Monotone Mixing .................................. 369
11.3.3 Order Mixing ..................................... 370
11.3.4 Order Reversing ................................... 371
11.4 Conclusion ........................................ 372

References ..................................... 372

12 Some Economic Applications of Recent Advances in Random Dynamical Systems .......................... 375

Santanu Roy

12.1 Introduction ..................................... 375
12.2 A Simple Economic Model of Capital Accumulation under Uncertainty ............................ 376
12.3 Long Run Behavior of the Economic System ........... 379

References ..................................... 382
Contents

13 Reprints: Part IV ......................................................... 385
   R.N. Bhattacharya and Coauthors
   13.1 “Dynamical systems subject to random shocks: an introduction” . . 386
   13.2 “Random iterates of monotone maps” .......................... 399

Part V Stochastic Foundations in Applied Sciences II: Geophysics

14 Advection-Dispersion in Fluid Media and Selected Works of Rabi
   Bhattacharya ............................................................... 411
   Enrique A. Thomann and Edward C. Waymire
   14.1 Introduction ...................................................... 411
   14.2 Brownian Motion in Porous Media and Taylor-Aris Dispersion . . 415
   14.3 Multiscale Dispersion ......................................... 417
   14.4 Discontinuous Coefficients and Skew Dispersion ................. 419
   14.5 Concluding Remarks ......................................... 420
   References ............................................................... 421

15 Cascade Representations for the Navier–Stokes Equations .......... 425
   Franco Flandoli and Marco Romito
   15.1 Introduction ...................................................... 425
   15.2 Fourier Formulation of the Navier–Stokes Equations ............ 426
   15.3 Picard Iteration and Deterministic Cascade Representation ...... 428
   15.4 Stochastic Cascade and Majorizing Kernels .................... 429
      15.4.1 The Stochastic Cascade of Le Jan and Sznitman ... 429
      15.4.2 Majorizing Kernels ........................................ 431
   15.5 Pruning the Trees ............................................... 432
      15.5.1 The Comparison Equation ............................... 432
      15.5.2 Pruning the Tree ....................................... 433
   References ............................................................... 434

16 Reprints: Part V .......................................................... 437
   R.N. Bhattacharya and Coauthors
   16.1 “On a statistical theory of solute transport in porous media” . . 438
   16.2 “On the Taylor-Aris theory of solute transport in a capillary” . . 453
   16.3 “Asymptotics of solute dispersion in periodic porous media” . . 461
   16.4 “Multiscale diffusion processes with periodic coefficients and an
        application to solute transport in porous media” ............ 475
   16.5 “Majorizing kernel and stochastic cascades with application
        to incompressible Navier Stokes equations” .................. 546

Part VI Stochastic Foundations in Applied Sciences III: Statistics

17 Nonparametric Statistical Methods on Manifolds .................. 587
   Ian L. Dryden, Huiiling Le, Simon P. Preston,
   and Andrew T.A. Wood
   17.1 Bootstrap Methods ............................................. 587
   17.2 Curve Fitting ..................................................... 591
   References ............................................................... 596
### 18 Nonparametric Statistics on Manifolds and Beyond
Stephan Huckemann and Thomas Hotz

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>18.1</td>
<td>Before “Large Sample Theory of Intrinsic and Extrinsic SampleMeans on Manifolds”</td>
<td>599</td>
</tr>
<tr>
<td>18.2</td>
<td>“Large Sample Theory of Intrinsic and Extrinsic SampleMeans on Manifolds”</td>
<td>601</td>
</tr>
<tr>
<td>18.3</td>
<td>Beyond “Large Sample Theory of Intrinsic and Extrinsic SampleMeans on Manifolds”</td>
<td>603</td>
</tr>
<tr>
<td>18.4</td>
<td>Conclusion</td>
<td>605</td>
</tr>
</tbody>
</table>

### 19 Reprints: Part VI
R.R. Bhattacharya and Coauthors

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>19.1</td>
<td>“Large sample theory of intrinsic and extrinsic samplemeans on manifolds, I”</td>
<td>612</td>
</tr>
<tr>
<td>19.2</td>
<td>“Large sample theory of intrinsic and extrinsic samplemeans on manifolds, II”</td>
<td>642</td>
</tr>
<tr>
<td>19.3</td>
<td>“Statistics on Riemannian manifolds: asymptotic distributionand curvature”</td>
<td>679</td>
</tr>
<tr>
<td>19.4</td>
<td>“Statistics on manifolds with applications to shape spaces”</td>
<td>689</td>
</tr>
</tbody>
</table>
Rabi N. Bhattacharya
Selected Papers
Denker, M.; Waymire, E.C. (Eds.)
2016, XXI, 711 p. 1 illus., Hardcover
ISBN: 978-3-319-30188-4
A product of Birkhäuser Basel