Contents

Preface v

Introduction xi
by Giacomo Albi, Stefano Almi, Nadia Loy, Marco Morandotti, and Francesco Solombrino
Background and scope xi
Topics covered in the volume xiii

1 Full synchronization in a Kuramoto mean field game 1
by Annalisa Cesaroni
1 Introduction 1
2 Ergodic Kuramoto mean field game 4
3 Self-organizing solutions to the MFG Kuramoto system 6
4 Full synchronization as $\kappa \to +\infty$ 8
5 Kuramoto mean field game system in a heterogeneous setting 11
References 14

2 Second-order swarming model: Large-time behavior and uniform-in-time mean-field limit 15
by Young-Pil Choi and Sihyun Song
1 Introduction 15
2 Large-time behavior: Exponential consensus 22
3 Uniform-in-time stability and mean-field limit 31
References 35

3 Propagation of chaos for topological models without regularity 37
by Marta Menci, Thierry Paul, and Stefano Rossi
1 Introduction 37
2 Topological interaction 39
3 Main result 42
4 Previous results 44
5 Proof of Theorem 3.1 46
6 Conclusion and perspectives 52
References 52

4 Non-local dissipative Aw–Rascle model and its relation with matrix-valued communication in Euler alignment 55
by Nilasis Chaudhuri, Jan Peszek, Maja Szlenk, and Ewelina Zatorska
1 Introduction 55
2 Notation 60
3 From micro- to mesoscopic DNAR dynamics 61
4 From meso- to macroscopic DNAR dynamics 65
5 Solutions to the DNAR system as a limit of particle dynamics 70
A Disintegration theorem 76
References 76

5 Controllability and kinetic limit of spherical particles immersed in a viscous fluid 79
by Marta Zoppello, Henry Shum, and Marco Morandotti
1 Introduction 79
2 Preliminaries 80
3 The model 81
4 Two controllability results 84
5 Kinetic limit 91
References 98

6 Deterministic particle method for nonlinear nonlocal scalar balance equations 101
by Emanuela Radici and Federico Stra
1 Introduction 101
2 Theoretical analysis 105
References 132

7 Kinetic models for optimization: A unified mathematical framework for metaheuristics 135
by Giacomo Borghi, Michael Herty, and Lorenzo Pareschi
1 Introduction 135
2 Simulated annealing 137
3 Genetic algorithm 144
4 Particle swarm optimization 154
5 Ensemble Kalman filter 162
6 Where we are and what is next 166
References 168

8 Localized kinetic-based optimization with genetic dynamics for multi-modal optimization . . . 175
by Federica Ferrarese and Claudia Totzeck
1 Introduction . . . 175
2 Localized genetic kinetic-based optimization . . . 177
3 Derivation of the mean-field equations . . . 180
4 Change of labels . . . 182
5 Numerical methods . . . 183
6 Validation tests . . . 186
7 Conclusion . . . 191
References . . . 192

9 Multi-fidelity and multi-level Monte Carlo methods for kinetic models of traffic flow . . . 195
by Elisa Iacomini and Lorenzo Pareschi
1 Introduction . . . 195
2 Kinetic models of traffic with uncertainties . . . 198
3 Multi-fidelity and multi-level methods . . . 200
4 Numerical results . . . 207
5 Conclusions . . . 214
References . . . 215

10 Patterns in the Keller–Segel system with density cut-off . . . 219
by Benoît Perthame and Mingyue Zhang
1 Introduction . . . 219
2 Energy, time decay, stability . . . 221
3 Uniqueness of the steady state in n dimensions and function $\Lambda(\cdot)$ . . . 227
4 Uniqueness of the steady state in dimension one and function G_λ . . . 231
5 Increasing steady states . . . 237
6 Numerical simulations . . . 251
References . . . 254

11 Derivation of macroscopic epidemic models from multi-agent systems . 257
by Mattia Zanella
1 Introduction . . . 257
2 From agent-based to mean-field models for contact formation dynamics . . . 258
3 Kinetic compartmental model and observable dynamics . . . 264
4 Numerical tests . . . 268
5 Concluding remarks and perspectives . . . 272

References 272

12 Voter demographics and socio-economic factors in kinetic models for opinion formation 277
by Bertram Düring and Oliver Wright
1 Introduction 277
2 Kinetic opinion formation model of Düring and Wright (2022) 279
3 Compromise function from demographic voter intention data 281
4 Numerical experiments 284
5 Application to the 2024 general election in the United Kingdom 286
References 295

13 A review of mechanistic and data-driven models of terrorism and radicalization 299
by Yao-Li Chuang and Maria R. D'Orsogna
1 Introduction 299
2 Background 302
3 Radicalization in opinion dynamics models 306
4 Radicalization and age structure 312
5 Lattice and network models 316
6 Game theoretic models of terrorism 330
7 Terrorist events as self-exciting processes 338
8 Terrorism through the lens of data 342
9 Summary and conclusions 353
References 355

List of contributors 383