

Table of contents

List of figures	xix
List of tables	xxv
1 Introduction	1
1.1 Historical foundations of modern science	1
1.2 The Emergence of Statistical Mechanics	2
1.2.1 Challenges in Defining Hamiltonian for Nonequilibrium Systems	3
1.2.2 Energy Dissipation	4
1.2.3 Detailed Balance Condition	4
1.2.4 Time-Reversal Symmetry	5
1.2.5 Entropy Production	7
1.2.6 Non-Equilibrium Steady States (NESS)	7
1.2.7 Fluctuation Theorems	8
1.2.8 Examples of Nonequilibrium Systems	9
1.3 Active Matter: A Subclass of Nonequilibrium Systems	9
1.4 Types of Active particles	10
1.5 Models to Study Active Systems	12
1.5.1 Microscopic Models	12
1.5.2 Coarse-Grained Models	14
1.6 Inhomogeneity in Active systems	15
1.6.1 Extrinsic Inhomogeneity	16
1.6.2 Intrinsic Inhomogeneity	17
1.7 Observables to characterize the system:	18
1.7.1 Ordering in the System	18
1.7.2 Ordering in Different Dimensions	19
1.7.3 Phase Transition	19
1.8 Organisation of the thesis	21

1.9	Technical details	21
2	Active polar flock with birth and death	23
2.1	Introduction	23
2.2	Model and Numerical Methodology	24
2.3	Results	27
2.4	Hydrodynamic equations of motion for slow variables	31
2.4.1	Perturbative calculation for effective free energy for local polarisation	35
2.5	Conclusion	39
3	Directional cues affect the collective behaviour of Self propelled particles in one dimension	41
3.1	Introduction	41
3.2	Model and Numerical Methodology	43
3.3	Results	46
3.4	Conclusion	53
4	Active Brownian particles can mimic the pattern of the substrate	55
4.1	Introduction	55
4.2	Model and Numerical Methodology	57
4.2.1	Moment Equations	57
4.3	Results	60
4.3.1	Coarse-grained model (CG)	60
4.3.2	Microscopic model (MIC)	65
4.4	Miscellaneous shapes	67
4.5	Conclusion	69
5	Polar particles induce strings in liquid crystal	71
5.1	Introduction	71
5.2	Model and Numerical Methodology	72
5.3	Numerical Details	75
5.4	Results	75
5.4.1	Artificial Defects in Coupled System	80
5.4.2	Confined System	81
5.5	Conclusion	84

6 Summary and Future Prospects	87
6.1 Summary	87
6.2 Future scope	89
Appendix	91
References	97
List of Publications	i