

# Contents

Preface	iii
Rationale	1
<b>1 Introduction: New Particle Physics from Astrophysics and Cosmology</b>	<b>3</b>
1.1 The Standard Model and why to go beyond . . . . .	3
1.1.1 The Hierarchy Problem . . . . .	5
1.1.2 Introduction to Extra Dimensions . . . . .	7
1.2 “Standard” neutrino physics and why to go beyond . . . . .	11
1.2.1 “What is left, what is next?” . . . . .	13
1.2.2 Sterile neutrinos . . . . .	15
1.3 The role of Supernovæ . . . . .	18
1.3.1 Supernova basics and neutrino signal formation . . . . .	18
1.3.2 The energy loss constraint . . . . .	21
1.3.3 Waiting for the next supernova . . . . .	23
1.4 The role of the Early Universe . . . . .	27
1.4.1 Big Bang Nucleosynthesis . . . . .	27
1.4.2 Large Scale Structure and Cosmic Microwave Background . . . . .	35
<b>2 A (4D) sterile neutrino</b>	<b>38</b>
2.1 Active-sterile neutrino mixing formalism . . . . .	38
2.2 Sterile effects in cosmology . . . . .	41
2.2.1 Technical details . . . . .	41
2.2.2 Results . . . . .	45
2.3 Sterile effects in Supernovæ . . . . .	48
2.3.1 Technical details . . . . .	50
2.3.2 Results . . . . .	54
<b>3 Neutrinos in Extra Dimensions</b>	<b>56</b>
3.1 The extra dimensional setup . . . . .	57
3.2 Cosmological safety (or irrelevance) . . . . .	58

3.3	Supernova core evolution . . . . .	58
3.3.1	The feedback mechanisms . . . . .	59
3.3.2	Details of the model of core evolution . . . . .	60
3.4	The outcome: bounds and signals . . . . .	70
3.5	Appendix: subleading invisible channels . . . . .	76
<b>4</b>	<b>Conclusions</b>	<b>77</b>
	<b>References</b>	<b>79</b>