1. Record Nr. UNISA996503462203316

Autore	Gouttenoire Yann
Titolo	Beyond the standard model cocktail : a modern and comprehensive review of the major open puzzles in theoretical particle physics and cosmology with a focus on heavy dark matter / / Yann Gouttenoire
Pubbl/distr/stampa	Cham, Switzerland : , : Springer Nature Switzerland AG, , [2022] ©2022
ISBN	9783031118623 9783031118616
Descrizione fisica	1 online resource (534 pages)
Collana	Springer Theses Series
Disciplina	539.72
Soggetti	Cosmology Particles (Nuclear physics)
Lingua di pubblicazione	Inglese
Formato	Materiale a stampa
Livello bibliografico	Monografia
Nota di bibliografia	Includes bibliographical references.
Nota di contenuto	Intro -- Supervisors' Foreword -- Abstract -- Publications Related to This Thesis -- Acknowledgements -- Contents -- About the Author -- 1 Introduction -- References -- 2 Standard Model of Elementary Particles -- 2.1 Fields and Symmetries -- 2.1.1 The Lorentz Representations -- 2.1.2 The Gauge Interactions -- 2.1.3 The Matter Content -- 2.1.4 The Higgs Field -- 2.2 The Standard Model in a Nutshell -- 2.2.1 The Lagrangian -- 2.2.2 Quantum Chromodynamics -- 2.2.3 Electroweak Symmetry Breaking -- 2.2.4 Weak CP Violation -- 2.2.5 Anomaly Cancellation -- 2.2.6 Strong CP Violation -- 2.3 Open Problems -- 2.3.1 Hierarchy Problem -- 2.3.2 Neutrino Oscillations -- 2.3.3 Flavor Hierarchy Problem -- 2.3.4 Strong CP Problem -- References -- 3 Standard Model of Cosmology -- 3.1 The normal upper LamdaCDM Cosmological Model -- 3.1.1 A Homogeneous and Isotropic Expanding Universe -- 3.1.2 Energy Content of the Universe -- 3.2 The Hot Big-Bang Scenario -- 3.2.1 Thermal Equilibrium -- 3.2.2 Beyond Thermal Equilibrium -- 3.3 Inflation -- 3.3.1 The Homogeneity Problem -- 3.3.2 The Flatness Problem -- 3.3.3 The Solution: Shrinking the Comoving Hubble Radius -- 3.3.4 Slow-Roll Inflation -- 3.4 Gravitational Waves of Primordial Origin -- 3.4.1 Linearized Wave Solutions of Einstein Equations -- 3.4.2 Energy of

Gravitational-Waves -- 3.4.3 Cosmological Signals -- 3.5 Open Problems -- 3.5.1 Cosmological Constant Problem -- 3.5.2 Matter-Anti-Matter Asymmetry -- 3.5.3 Dark Matter Puzzle -- 3.5.4 The Fragility of normal upper LamdaCDM -- 3.5.5 The Hubble Tension -- 3.5.6 The 21-cm Anomaly -- References -- 4 Thermal Dark Matter -- 4.1 Production Mechanism -- 4.1.1 The Boltzmann Equation -- 4.1.2 Freeze-In Versus Freeze-Out -- 4.1.3 Exceptions -- 4.2 The WIMP Paradigm -- 4.2.1 Motivations -- 4.2.2 The WIMP Abundance -- 4.2.3 Minimal WIMP Under Pressure.
4.2.4 Warm Dark Matter -- 4.3 Heavy WIMP -- 4.3.1 Breakdown of Perturbation Theory -- 4.3.2 Sommerfeld Enhancement -- 4.3.3 Bound-State-Formation -- 4.3.4 The Unitary Bound -- 4.A Unitary Bound on Cross-Sections -- 4.A.1 Partial-Wave Expansion of the Cross-Section -- 4.A.2 Unitarity of the Partial-Wave Expansion -- 4.B Computation of the Sommerfeld Factor -- 4.B.1 The Schrödinger Equation -- 4.B.2 Coulomb Potential -- 4.B.3 Yukawa Potential -- References -- 5 Homeopathic Dark Matter -- 5.1 Introduction -- 5.2 Relaxing the Unitarity Bound By Injecting Entropy -- 5.2.1 The Start of the Matter Era -- 5.2.2 The End of the Matter Era -- 5.2.3 Dilution by Entropy Injection -- 5.2.4 Impact on Unitary Bound -- 5.3 The Dark bold upper U bold left parenthesis bold 1 bold right parenthesisU(1) Model as a Case of Study -- 5.3.1 The Lagrangian -- 5.3.2 Dark Photon -- 5.3.3 DM Relic Abundance and Dilution -- 5.3.4 DM Signals -- 5.4 Phenomenology -- 5.4.1 Constraints on the Kinetic Mixing -- 5.4.2 DM Constraints from the Early Universe -- 5.4.3 DM Constraints from the Local Universe -- 5.4.4 On the Dark Photon Emitted During the Formation of Bound States -- 5.5 Summary and Outlook -- 5.A upper U left parenthesis 1 right parenthesis Subscript upper DU(1)D Coupled to Hypercharge upper U left parenthesis 1 right parenthesis Subscript upper YU(1)Y -- 5.A.1 The Lagrangian -- 5.A.2 Gauge Eigenstates Versus Mass Eigenstates -- 5.A.3 Dark Photon Interaction with SM -- 5. B Dark Photon Decay Widths -- 5.C Gamma Ray from DM Annihilation -- References -- 6 First-Order Cosmological Phase Transition -- 6.1 Bubble Nucleation -- 6.1.1 Effective Potential at Finite Temperature -- 6.1.2 Tunneling Rate -- 6.1.3 Thin-Wall and Thick-Wall Limits -- 6.1.4 Temperature at Which the Phase Transition Completes -- 6.2 Bubble Propagation -- 6.2.1 Equation of Motion for the Scalar Field.
6.2.2 Friction Pressure at Local Thermal Equilibrium -- 6.2.3 Friction Pressure Close to Local Thermal Equilibrium -- 6.2.4 Friction Pressure in the Ballistic Approximation -- 6.2.5 Friction Pressure at NLO -- 6.2.6 Speed of the Wall -- 6.3 GW Generation -- 6.3.1 The GW Spectrum for a Generic Source -- 6.3.2 Contribution from the Scalar Field -- 6.3.3 Contributions from Sound Waves and Turbulence -- 6.3.4 Energy Transfer to Sound-Waves -- 6.4 Supercooling from a Nearly-Conformal Sector -- 6.4.1 Weakly-coupled Scenario: The Coleman-Weinberg Potential -- 6.4.2 Strongly-Coupled Scenario: The Light-Dilaton Potential -- 6.A Sensitivity Curves of GW Detectors -- 6.A.1 The Signal-to-Noise Ratio -- 6.A.2 The Power-Law Integrated Sensitivity Curve -- 6.A.3 Results -- References -- 7 String Fragmentation in Supercooled Confinement and Implications for Dark Matter -- 7.1 Introduction -- 7.2 Synopsis -- 7.3 Supercooling Before Confinement -- 7.3.1 Strongly Coupled CFT -- 7.3.2 Thermal History -- 7.3.3 Dilution of the Degrees of Freedom -- 7.4 Confinement and String Fragmentation -- 7.4.1 Where Does Confinement Happen? -- 7.4.2 Fluxtubes Attach to the Wall Following Supercooling -- 7.4.3 String Energy and Boost Factors -- 7.4.4 Hadrons from String Fragmentation: Multiplicity and Energy -- 7.4.5 Enhancement of Number Density from String Fragmentation -- 7.4.6 Ejected Quarks and Gluons and Their Energy Budget -- 7.5

Bubble Wall Velocities -- 7.5.1 LO Pressure -- 7.5.2 NLO Pressure -- 7.5.3 Ping-Pong Regime -- 7.6 Amount of Supercooling Needed for Our Picture to Be Relevant -- 7.7 Ejected Quarks and Gluons -- 7.7.1 Density of Ejected Techniquanta -- 7.7.2 Scatterings of Ejected Quarks and Gluons Before Reaching Other Bubbles -- 7.7.3 Ejected Techniquanta Enter Other Bubbles (and Their Pressure on Them) -- 7.7.4 Ejected Techniquanta Heat the Diluted SM Bath.
7.8 Deep Inelastic Scattering in the Early Universe -- 7.8.1 Scatterings Before (P)reheating -- 7.8.2 Scatterings with the (P)reheated Bath -- 7.8.3 Enhancement of Hadron Abundance Via DIS -- 7.8.4 DIS Summary -- 7.9 Supercooled Composite Dark Matter -- 7.9.1 Initial Condition for Thermal Evolution -- 7.9.2 Thermal Contribution -- 7.9.3 Dark Matter Relic Abundance -- 7.10 Discussion and Outlook -- 7.A Wall Profile of the Expanding Bubbles -- 7.A.1 The Light-Dilaton Potential -- 7.A.2 The Wall Profile -- 7.B Example Estimates of the String to DM Branching Ratio -- 7.B.1 Light Meson-Combinatorics -- 7. B.2 Heavy Baryon-Boltzmann Suppression -- References -- 8 Gravitational Waves from Cosmic Strings -- 8.1 Introduction -- 8.2 Recap on Cosmic Strings -- 8.2.1 Microscopic Origin of Cosmic Strings -- 8.2.2 Cosmic-String Network Formation and Evolution -- 8.2.3 Decay Channels of Cosmic Strings -- 8.2.4 Constraints on the String Tension upper G muG μ from GW Emission -- 8.3 Gravitational Waves from Cosmic Strings -- 8.3.1 Beyond the Nambu-Goto Approximation -- 8.3.2 Assumptions on the Loop Distribution -- 8.3.3 The Gravitational-Wave Spectrum -- 8.3.4 The Frequency-Temperature Relation -- 8.3.5 The Astrophysical Foreground -- 8.4 The Velocity-Dependent One-Scale Model -- 8.4.1 The Loop-Production Efficiency -- 8.4.2 The VOS Equations -- 8.4.3 Scaling Regime Solution and Beyond -- 8.5 Standard Cosmology -- 8.5.1 The Cosmic Expansion -- 8.5.2 Gravitational Wave Spectrum -- 8.5.3 Deviation from the Scaling Regime -- 8.5.4 Beyond the Nambu-Goto Approximation -- 8.6 Intermediate Matter Era -- 8.6.1 The Non-standard Scenario -- 8.6.2 Impact on the Spectrum -- 8.6.3 Constraints -- 8.7 Intermediate Inflation -- 8.7.1 The Non-standard Scenario -- 8.7.2 The Stretching Regime and Its Impact on the Spectrum -- 8.7.3 Model-Independent Constraints.
8.8 Summary and Conclusion -- 8.A Constraints on Cosmic Strings from BBN, Gravitational … -- 8.A.1 GW Constraints from BBN -- 8.A.2 Gravitational Lensing -- 8.A.3 Temperature Anisotropies in the CMB -- 8.A.4 Non-gravitational Radiation -- 8.B Derivation of the GW Spectrum from CS -- 8.B.1 From GW Emission to Detection -- 8.B.2 From Loop Production to GW Emission -- 8.B.3 The Loop Production -- 8.B.4 The Master Equation -- 8.B.5 The GW Spectrum from the Quadrupole Formula -- 8.B.6 Impact of the High-Frequency Proper Modes of the Loop -- 8.C Derivation of the Frequency-Temperature Relation -- 8.C.1 In Standard Cosmology -- 8.C.2 During a Change of Cosmology -- 8.C. 3 In the Presence of an Intermediate Inflation Period -- 8.C.4 Cut-Off from Particle Production -- 8.D Derivation of the VOS Equations -- 8.D. 1 The Nambu-Goto String in an Expanding Universe -- 8.D.2 The Long-String Network -- 8.D.3 VOS 1: The Correlation Length -- 8.D.4 Thermal Friction -- 8.D.5 VOS 2: The Mean Velocity -- 8.E Extension of the Original VOS Model -- 8.E.1 VOS Model from Nambu-Goto Simulations -- 8.E.2 VOS Model from Abelian-Higgs Simulations -- 8.E. 3 VOS Model from Abelian-Higgs Simulations with Particle Production -- 8.F GW Spectrum from Global Strings -- 8.F.1 The Presence of a Massless Mode -- 8.F.2 Evolution of the Global Network -- 8.F.3 The GW Spectrum -- 8.F.4 Global Versus Local Strings -- 8.F.5 As a Probe of Non-standard Cosmology -- References -- 9 Probe Heavy DM with

GW from CS -- 9.1 The Imprints of an Early Era of Matter Domination -- 9.1.1 Modified Spectral Index -- 9.1.2 How to Detect a Matter Era with a GW Interferometer -- 9.1.3 Model-Independent Constraints on Particle Physics Parameters -- 9.1.4 Heavy Dark Photons -- 9.2 Supercooled Composite Dark Matter -- 9.3 Summary -- References -- 10 Conclusion -- References.