PHYS 743 Fall 2023 Prof. R. Brandenberger

VERY EARLY UNIVERSE

Readings

Week 1: Review of Standard Cosmology and its Problems

* W. H. Kinney, "TASI Lectures on Inflation," arXiv:0902.1529 [astro-ph.CO]; Sections 1 - 3.

* R. H. Brandenberger, "Inflationary cosmology: Progress and problems," arXiv:hep-ph/9910410; Section 2.

Week 2: Inflationary Universe Scenario

* W. H. Kinney, "TASI Lectures on Inflation," arXiv:0902.1529 [astro-ph.CO]; Sections 4.

* R. H. Brandenberger, "Inflationary cosmology: Progress and problems," arXiv:hep-ph/9910410; Section 3.

Weeks 3 and 4: Theory of Cosmological Perturbations

* R. H. Brandenberger, "Lectures on the theory of cosmological perturbations," Lect. Notes Phys. **646**, 127 (2004) [arXiv:hep-th/0306071]; Sections 2 - 4.

Weeks 5: Alternatives to Inflation

* R. H. Brandenberger, "Introduction to Early Universe Cosmology," PoS **ICFI2010**, 001 (2010). [arXiv:1103.2271 [astro-ph.CO]]; Sections 1.4 - 1.6, 3.5, 4.1 - 4.2, 5.1 - 5.2.

* A. Bedroya, R. Brandenberger, M. Loverde and C. Vafa, "Trans-Planckian Censorship and Inflationary Cosmology," Phys. Rev. D **101**, no.10, 103502 (2020) doi:10.1103/PhysRevD.101.103502 [arXiv:1909.11106 [hep-th]].

Week 6: Topological Defects and Structure Formation

* R. Brandenberger, "Topological defects and structure formation," Int. J. Mod. Phys. A **9**, 2117 (1994) [arXiv:astro-ph/9310041]. Emphasis on Sections 3.1 - 3.7, 4.1, 4.2, 4.3 (omit (4.19 - 4.30)), 4.4, 6, 8.3.

'* R. Brandenberger, "Searching for Cosmic Strings in New Observational Window", arXiv:1301.2856.

Week 7: Parametric Resonance and Reheating in Inflation

* M. Amin et al, arXiv:1410.3808, Sections 1 - 3

* R. Allahverdi et al, arXiv:1001.2600; Sections 1 - 3 (with emphasis on Section 3).

Week 11: Elements of Superstring Cosmology

* R. Brandenberger, "Superstring Cosmology – A Complementary Review," [arXiv:2306.12458 [hep-th]].

* T. D. Brennan, F. Carta and C. Vafa, "The String Landscape, the Swampland, and the Missing Corner," PoS TASI **2017**, 015 (2017) arXiv:1711.00864 [hep-th], Section 2

* D. Baumann "TASI Lectures on Inflation," arXiv:0907.4524; Secs. 28 and 29.

* S. Brahma, R. Brandenberger and S. Laliberte, "BFSS Matrix Model Cosmology: Progress and Challenges," [arXiv:2210.07288 [hep-th]].

Week 9: Cosmic Microwave Background Anisotropies

* D. Baumann, "TASI Lectures on Primordial Cosmology", arXiv:1807.03098, Sections 3 and 4.

* W. Hu and S. Dodelson, "Cosmic Microwave Background Anisotropies", astro-ph/0110414, up to and including subsection 4.2

* Planck Collaboration, "Planck 2013 results: XVI. Cosmological parameters" arXiv:1303.5076. Supplementary reading for recent observational results. Focus on Fig. 1 and Table 2

Week 10: Gravitational Waves

* M. Maggiore, "Gravitational wave experiments and early universe cosmology," arXiv:gr-qc/9909001; Sec. 1, Sects. 8 - 10 excluding 9.3.

* LIGO and Virgo collaborations, "Observation of Gravitational Waves from a Binary Black Hole Merger," Phys. Rev. Lett. **116**, no. 6, 061102 (2016) arXiv:1602.03837.

* LIGO Scientific and Virgo and Fermi GBM and INTEGRAL and IceCube and IPN and Insight-Hxmt and ANTARES and Swift and Dark Energy Camera GW-EM and Dark Energy Survey and DLT40 and GRAWITA and Fermi-LAT and ATCA and ASKAP and OzGrav and DWF (Deeper Wider Faster Program) and AST3 and CAASTRO and VINROUGE and MASTER and J-GEM and GROWTH and JAGWAR and CaltechNRAO and TTU-NRAO and NuSTAR and Pan-STARRS and KU and Nordic Optical Telescope and ePESSTO and GROND and Texas Tech University and TOROS and BOOTES and MWA and CALET and IKI-GW Follow-up and H.E.S.S. and LOFAR and LWA and HAWC and Pierre Auger and ALMA and Pi of Sky and DFN and ATLAS Telescopes and High Time Resolution Universe Survey and RIMAS and RATIR and SKA South Africa/MeerKAT Collaborations and AstroSat Cadmium Zinc Telluride Imager Team and AGILE Team and 1M2H Team and Las Cumbres Observatory Group and MAXI Team and TZAC Consortium and SALT Group and Euro VLBI Team and Chandra Team at McGill University], "Multi-messenger Observations of a Binary Neutron Star Merger," Astrophys. J. **848**, no. 2, L12 (2017) [arXiv:1710.05833 [astro-ph.HE]].

* G. Agazie *et al.* [NANOGrav], "The NANOGrav 15 yr Data Set: Evidence

for a Gravitational-wave Background," Astrophys. J. Lett. **951**, no.1, L8 (2023) doi:10.3847/2041-8213/acdac6 [arXiv:2306.16213 [astro-ph.HE]].

Week 11: Dark Energy

* M. Li, X-D. Li, S. Wang and Y. Wang, "Dark Energy," arXiv:1103.5870, Sections 1 and 2.

* C. Burgess, "The Cosmological Constant Problem: Why it's so hard to get Dark Energy from Microphysics", arXiv:1309.4133, Section 1.

Weeks 12: Quantum Field Theory Methods in Cosmology

* R. Brandenberger, "Quantum field theory methods and inflationary universe models", Rev. Mod. Phys. **57**, 1 (1985); Sections II - IV (Effective potential, finite temperature field theory, bubble nucleation).