In the name of God

Department of Physics
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MODERN COSMOLOGY

Exercise Set 3

(Due Date: 1404/02/12)

1. According to paper written by Scott Dodelson and Mika Vesterinen entitle " *Cosmic Neutrino Last Scattering Surface*", PRL 103, 171301 (2009), do following task:

A : Using the relevant equations plot distance to CNB last scattering for various values of m_ν(eV).

B : Plot the optical depth for CNB as a function of distance to CNB last scattering.

2. By using the Friedmann first equation and continuity equation, derive equation for acceleration.

3. By using the Friedmann second equation and continuity equation, derive equation for $\dot{a}/a$.

4. Based on the results you obtained from two previous question, deduce that why the footprint of pressure is not present in the first Friedmann equation.

5. According to the variation of action, δS_{GR}, derive the Einstein field equation. After that by taking the FLRW metric in an expanding and flat universe, derive Friedmann equations.

6. Solve 3-1, 3-2, 3-3, 3-4, 3-5 and 3-6 exercises of chapter 3, Modern Cosmology Book written by S. Dodelson and F. Schmidt, 2021 edition.

Good luck, Movahed