

In the name of God

Department of Physics  
Shahid Beheshti University

ADVANCED TOPICS IN MODERN COSMOLOGY

Exercise Set 5

(Date Due: 1393/08/20)

1. Energy-momentum conservation in general relativity. Using the general form of  $T_{\mu\nu} = \rho u_\mu u_\nu + P\gamma_{\mu\nu} + q_\mu u_\nu + \pi_{\mu\nu}$ , derive continuity and Euler equations. Where  $\rho = T_{\mu\nu}u^\mu u^\nu$ ,  $P = T_{\mu\nu}\gamma^{\mu\nu}/3$ ,  $q^\mu = -T_{\alpha\beta}u^\alpha\gamma^{\beta\mu}$ ,  $\pi_{\mu\nu}$  is anisotropic pressure tensor,  $\gamma_{\mu\nu}$  is 3D Riemannian metric. Use the signature  $(-, +, +, +)$ .
2. Using Einstein equation as  $R_{\mu\nu} - \frac{1}{2}Rg_{\mu\nu} = 8\pi GT_{\mu\nu}$ , and  $ds^2 = g_{\mu\nu}dx^\mu dx^\nu$ , where  $g_{\mu\nu} = (c^2, -\frac{a^2(t)}{1-kr^2}, -a^2(t)r^2, -a^2(t)r^2 \sin^2(\theta))$ . For Ideal flow, derive equation evolution for scale factor. Do the same if the cosmological constant to be added in mentioned equation.

Good luck, Movahed

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