M.Sc.(PHYSICS), IV-Semester Internal Assessment 2018 March, University of Delhi
Paper-PHYS-576: General Theory of Relativity & Cosmology-II

Time: 90 minutes

Maximum Marks: 30

(Write your Roll No. on the top of this question paper immediately on receipt)

All notations have their usual meaning.

1(a) Why conformal time is significant in cosmology?

With a power-law scale factor a cosmological space-time is: $ds^2 = -dt^2 + t^{2q}\left(dr^2 + r^2 d\Omega^2\right)$, where $0<q<1$ is a constant. Find the range of each causal coordinate.

Use $\eta = \dfrac{t^{1-q}}{1-q}$ to reexpress ds^2 and justify a name given to the coordinate transformation.

(b) Explain how tortoise coordinates resolve the issue with the lightcone at the event horizon (in static coordinates) of a Schwarzschild black hole? Draw appropriate diagram(s).

(5+5)-marks

2(a) Begin with the Reissner-Nordstrom line-element (mention the coupling G) and obtain an expression for an extremal black hole in isotropic coordinates.

Perform mathematical analysis to give reason behind the isotropic nature of coordinates.

(b) Use the result in Q.2(a) to interpret a multi (extremal) black hole metric in terms of charges Q_a. Why is it an exact solution?

(5+2+3)-marks

3(a) What is quintessence? Briefly state the quintessence cosmology?

(b) Begin with an appropriate scalar field theory and derive an expression for the energy-momentum tensor which sources the quintessence.

(c) Use $\omega = (p/\rho)$ and re-express it in terms of the components of energy-momentum tensor. Obtain the equation of state for the quintessence and discuss the range of ω. Explain if quintessence can be a candidate for the dark energy.

(2+4+4)-marks