Quantum Gravity and Black Holes: Questions on Lecture 3

January 22, 2016

Rindler Space and Hawking Radiation

1. Why the change in coordinates made eq. (3.8) not be a solution of Einstein's equation?

2. QFT at finite temperature is periodic in imaginary time. What is the physical meaning of this?

3. Can someone clarify the steps from Eq. (3.11) to Eq. (3.14)?

4. How can we obtain eq. (3.16)?

5. Just to be clear, is this statement true? Every metric that has a behavior like Rindler in some region, then this implies that if we quantize some field around that background there is some Hawking-like temperature. Also, connection with last dot in pg.33:

   > According to the equivalence principle, sitting still in a uniform gravitational field is the same as accelerating. So do observers sitting near a massive object see Unruh radiation? Only if its a black hole (as discussed below). Observers sitting on Earth do not see Unruh radiation because the quantum fields near the Earth are not in the state (3.23). This is similar to the answer to the question 'why doesnt an electron sitting on the Earths surface radiate?'.

6. Why doesn't an electron sitting on the Earth's surface radiate?

7. If the Rindler observer is an observer in a uniformly accelerating trajectory, how is it possible that the Rindler vacuum corresponds to a state with no radiation? (pg 35 (3a))

8. Discussion of 5. pg 36:

   > In Rindler space, an observer on a geodesic (i.e., Minkowski observer) falls through the Rindler horizon, and this observer does not see the Unruh radiation. Similarly, you might expect that freely falling observers jumping into a black hole will not see Hawking radiation. This is almost correct, as long as the infalling observer is near the horizon in the approximately-Rindler region, but not entirely the potential barrier between the horizon and r = 1 causes some of the radiation to bounce back into the black hole, and this can be visible to an infalling observer.

9. Let us consider the state of an astrophysical black hole (BH) formed by gravitational collapse. If you have a single such black hole in an otherwise empty universe (not asymptotically AdS, nor with reflecting boundary conditions), you would have an Unruh vacuum: the BH radiates at temperature T, but the surroundings have zero temperature. Now, assume that instead of a single BH formed by gravitational collapse, you have infinitely many such black holes which all radiate with temperature T. Would the infinite family of Unruh states eventually equilibrate at late times into an infinite family of Hartle-Hawking states, i.e. would all the BHs be in thermodynamics equilibrium with one another and with the surroundings? If the BHs do not have all the same temperature when they collapse, would they reach a thermal-averaged temperature at thermodynamics equilibrium?