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http://www.uio.no/studier/emner/matnat/fys/FYS4160/v24/

Lecture spring 2024:

General Relativity

Problem sheet 9

⇝ These problems are scheduled for discussion on **Thursday, 4 April 2024**.

Problem 29

Consider an observer in the Schwarzschild geometry that is stationary with respect to the standard Schwarzschild coordinates, e.g. because she is sitting on the surface of a planet. Calculate the acceleration this observer experiences, as given by the magnitude of $d^2x^i/d\tau^2$. *(Hint: First re-write this as the covariant directional derivative of the 4-velocity. Why?)*. Discuss the result in light of the Newtonian expectation!

Problem 30

In the (online) lecture we just introduced Eddington-Finkelstein coordinates to describe the Schwarzschild solution,

$$v \equiv t + r^* \,,$$

$$u \equiv t - r^* \,,$$

where $r^* = r + R_s \log(r/R_s - 1)$. Here, $R_s = 2GM$ is the Schwarzschild radius, and r, t are the radial and time coordinates of the Schwarzschild metric. Show explicitly that ingoing radial null geodesics are characterized by $v = const.$, while outgoing radial null geodesics are given by $u = const.$ Determine (again) the form of radial light cones for the different coordinate choices – i.e. (t, r) vs. (v, r) vs. (u, r) – and discuss qualitatively the interpretation of the behaviour of the light cones around $r = R_s$.

Problem 31

Do the very instructive exercise 5.5 in the book by Carroll, i.e. study how an object falling into a black hole appears to a distant observer!