

General Relativity (I)

homework for week 2

due: Oct. 5th, 2020

1. [invisible Lorentz contraction/ download and read paper] 30%

The idea of Lorentz contraction is about the *measurement* of length *simultaneously* in the inertial observer's frame. In comparison, when we "see" a moving object, we receive photons emitted from the object at the *different time* object but arrive our eyes at the *same time*. Visual effects when "seeing" objects move at nearly the speed of light is demonstrated in the paper "[First-person visualizations of the special and general theory of relativity](#)" by U Kraus (2008, Eur. J. Phys. 29, 1):

(a) explain the physics behind figure 1 of the paper.

(b) In (a), the dice is moving from *left to right*. If the dice is moving from *right to left*, how would the result change and why?

(p.s. you can download the paper when using the NTNU internet.)

2. [superluminal motion/ find resources] 10%

When an object moving with a speed close to the speed of light, its transverse velocity on the sky may seem faster than the speed of light to a distant observer. Find related references (e.g. Box 4.3 of "Gravity: an introduction to Einstein's general relativity" by James B. Hartle, and/or google the key word) and explain such visual illusion with more details.

(p.s. also write down the reference(s) you find and read.)

3. [four vectors] 60%

In the inertial frame \mathcal{O} , given $\mathbf{A} = (0, 2, -4, 1)$ and $\mathbf{B} = (6, 4, 0, 3)$:

(a) what are the components: A^1, A^1, B^0, B_0 ?

(b) Is \mathbf{A} time-like, space-like, or null-like? how about \mathbf{B} ?

(c) compute $A^\alpha B_\alpha$

(d) find the components of \mathbf{A} in another inertial frame \mathcal{O}' , which moves at a speed of $0.8c$ with respect to \mathcal{O} in the positive x direction.

(e) find the components of \mathbf{B} in another inertial frame \mathcal{O}' .

(f) compute $A^\alpha B_\alpha$ in \mathcal{O}' frame.