Theoretische Physik 2 (Elektrodynamik) WS 2018/2019
Technische Universität München
January 25, 2019

Exercise Sheet 12*

Deadline: Sheet to be turned in by Friday 1st of February 2019 by 12 pm in the mailbox next to PH3218.

Exercise 1:
Modulation of a plane wave **2 Points**

Consider two linearly polarized plane waves moving in the z direction with the same amplitudes, E_0, the same polarization direction, frequencies $\omega+\delta\omega$, $\omega-\delta\omega$ and wave numbers $k+\delta k$, $k-\delta k$, respectively. Let $\delta\omega$ be much smaller than ω.

(a) What is the composite wave? Show that the amplitude of the composite wave is not a constant.

(b) Derive the phase velocity and group velocity of the composite wave.

Hint: The group velocity is the propagation velocity of the amplitude.

Exercise 2:
Length contraction, Time dilation and the Relativity of Simultaneity **3 Points**

Let a bus with length l_0 when at rest, move with velocity v in x direction on the road.

1. What is the length of the bus measured by an observer A who is at rest on the road.
2. Now let a ball move with velocity u_0' (in the bus system) from one end to the other on the bus. What is the time interval the ball takes while moving from one end to the other, as measured by A?
3. Suppose a passenger B on the bus releases two beams of light at the center of the bus, then these two light beams will arrive at the two ends of the bus simultaneously according to B. Is this still true for A? If not, what is the time difference?

Exercise 3:
Event coordinates in different inertial systems **2 Points**

Let Σ and Σ' be two inertial frames, where Σ' is moving relative to Σ with a speed $v = 4c/5$ in the z-direction. Both systems coincide at $t = t' = 0$. Given an event in Σ' with coordinates:

$$x' = 5\,\mathrm{m}, \qquad y' = 25\,\mathrm{m}, \qquad z' = 32\,\mathrm{m} \quad \text{and} \quad t' = 6\times10^{-8}\,\mathrm{s}, \tag{1}$$

find the coordinates of this event in the Σ reference frame.

*Responsible for the sheet: Juan S. Cruz, Office 1112, juan.cruz@tum.de

Exercise 4:
Lorentz transformations and angles **3 Points**

Let Σ and Σ' be two inertial frames that moving away from each other with a constant relative speed $\mathbf{v} = v\hat{z}$.

(a) A rod at rest in the Σ frame encloses an angle of 45° with respect to the z-axis. What angle does it have in the Σ' frame?

(b) Given a particle with speed $\mathbf{u} = (v, 0, 2v)$ in the Σ frame. What is the angle enclosed by its trajectory and the z-axis in the Σ and Σ' frames?

(c) A photon leaves the origin of Σ at $t = 0$ in a direction enclosing a 45° angle with the z-axis, what is the corresponding angle in Σ'.