Special and General Relativity PHZ 4601 Midterm October 17 Fall 2018.

1. **An astrophysical observation (40%):**

   For light from some galaxy the spectrum

   $$\lambda = (729.2\,[nm])\, m^2/(m^2-4)\,, \quad m = 3,\, 4,\, 5,\, \ldots$$

   is observed. Find the speed at which the galaxy moves away or towards us (ignore the possibility of transverse motion and the expansion of space). Note: In quantum mechanics books you find for the Balmer spectrum of the hydrogen atom $\lambda = (364.56\,[nm])\, m^2/(m^2-4)$, and the relativistic Doppler equation reads $\omega'/\omega = \sqrt{(1-\beta)/(1+\beta)}$.

2. **Light signals and travel in two inertial frames (40%):**

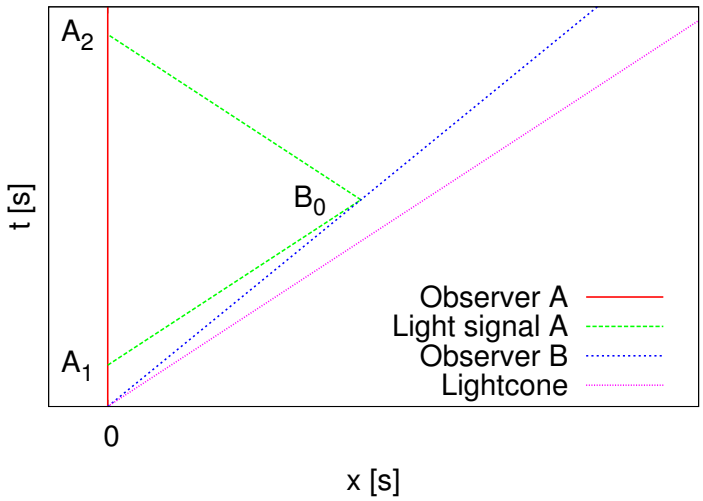

Figure: Minkowski space in which observer A is at rest and flashes a light signal at observer B, who moves with speed 4/5 and flashes the signal back.

In the above figure Minkowski space is parametrized by the coordinates of the rest frame S of an observer A. We use units of seconds $[s]$ and $c = 1$ for the speed of light. While observer A stays at rest, observer B moves with speed $\beta = 4/5$ along the positive x axis. At their common origin both, A and B, have set their clocks to zero. After 15 $[s]$ observer A emits at position A_1, i.e. at $(15\,[s], 0)$, a light signal which reaches observer B at position B_0, who flashes it back at observer A, who receives it at position A_2 as drawn in the figure.

(a) Find the coordinates of A_1 in the rest frame S' of B, where the translational freedom is used so that the origins of the restframes of A and B agree at time $t = t' = 0$.

(b) Find the coordinates of B_0 in the rest frames S of A and S' of B.

(c) Find the coordinates of A_2 in the rest frames S of A and S' of B.

(d) Transform the above figure into the rest frame S' of B (draw the resulting figure).

3. **Space travel (20%):**

A spaceship travels with uniform speed to a star 8 light-years away, in a time the crew considers to be 8 years. Find the speed of the spaceship.