

AST 231 Problem Set 2 (Due 5pm 10/3/08 in B&L A231 Locker)

1. Book Problem 5.1
2. Book Problem 5.2
3. Book Problem 5.8

4. An *alpha* particle (Helium ion) of mass 6.7×10^{-23} grams traveling at speed $4c/5$ and enters a concrete attenuation shield of thickness 35cm. The particle emerges from the other side of the concrete with speed $5c/13$. For the laboratory frame, assume that the rate of change of the particle momentum while in the shield is a constant value F .

(a) Calculate F .

(b) As measured in the laboratory frame, how long does it take for the particle to pass through the shield?

5. At the radius of the Earth's orbit around the sun (1.5×10^{13} cm = 1AU), the flux of radiation from the sun is $10^6 \frac{\text{erg}}{\text{cm}^2 \cdot \text{sec}}$. Now consider a spherical dust grain of radius r with internal density $\rho = 2\text{g/cm}^3$, at some distance R from the sun. Assume that the grain is at rest with respect to the sun. **Use the fact that radiation flux falls off with distance from a source as $1/R^2$** Ignore the gravity of the Earth in this problem, but not the gravity of the Sun. Use Newtonian gravity and ignore general relativistic effects.

(a) Find the critical size of the dust grain r_c that determines whether the grain will get blown away from the sun versus fall into it and write the inequality describing the behavior of the grain for $r < r_c$ and $r > r_c$.

(b) Suppose the grain is instead at $10R$, how does this affect the result of (a) ?

6. Suppose an object moving with speed v in the lab frame brightens and dims periodically with a frequency $\omega^* = 1/\Delta t^*$ in its rest frame.

(a) Determine the frequency of this flickering in the lab frame if synchronized clocks were available everywhere in the lab frame.

(b) Now suppose that you are at a fixed location and the object is moving toward you. Calculate the frequency of the flickering you would observe with your specific clock. Does this differ from part a? why or why not?

(c) If the observed flickering time **corresponds to a disturbance moving at light speed across the emitter (i.e. perpendicular to the direction of motion)**, find an expression for the **rest frame** size of the emitter **in terms of the observed flickering time** and **compare** the relative values for non-relativistic vs. highly relativistic motion.

7. A particle of mass $42M$ at rest decays into two fragments, one of which has rest mass $20M$ and speed $3c/5$. Find the momentum, energy, rest mass and speed of the other fragment.