Recitation 8

Week of 24 October 2011

Useful Equations and Conversions:

1 year = 365.25 days

Relativity of Mass  \( m = \frac{m_0}{\sqrt{1 - v^2/c^2}} \)

Luminosity = Energy/time

Energy radiated = efficiency \times\text{ total energy}

Mass-Energy Equivalence  \( E = mc^2 \)

Problems:

1) You and a friend decide you want to smash a pumpkin with a baseball bat and test the relativity of mass at the same time. At rest the pumpkin has a mass of 10,000 (10^4) grams. You toss the pumpkin to your friend and it reaches an impressive speed of 0.9c just before your friend smashes it with a bat. What is the pumpkin’s mass in flight just before it is smashed?

2) A black hole in a certain quasar accretes 1 solar mass of matter per year. Through accretion, suppose this quasar turns 10% of this mass into energy in the form of light. What is its luminosity in solar luminosities?
3) A black hole has a mass of $2 \times 10^6$ solar masses but the central object has a luminosity of $1 \times 10^5$ solar luminosities at most. Assuming the black hole converts mass into radiated energy at 10% efficiency, what is the maximum rate at which the black hole is could be accreting matter?

4) A certain star is in orbit with a faint companion. From Earth we see the system edge-on. Its speed in orbit is 80 km/s. The overall velocity of the two star system (that is, the velocity of their center of mass) along the line of sight is 100 km/s.

a. Draw a picture of the system.

b. Indicate on the picture where in the stars orbit we would see a maximum Doppler shift. What is the maximum wavelength (in centimeters) of a Doppler-shifted absorption line which, seen at rest, has a wavelength of 5.0000e-5 cm?

c. Indicate on the picture where in the stars orbit we would see a minimum Doppler shift. What is the minimum wavelength (in centimeters) of a Doppler-shifted absorption line which, seen at rest, has a wavelength of 5.0000e-5 cm?