Name: .....

ASTRONOMY 1102 - Section 1

Instructor: Juhan Frank
Spring 1999

Homework # 8 due Wed. Apr. 21st

Our Galaxy: the Milky Way

1) Use Kepler's law as modified by Newton

$P^2 = a^3/M$,

where P is the orbital period in years, a is the average distance in AU and M is the total mass in solar masses $M_\odot$, to estimate the mass of the Milky Way inside the solar orbit. The galactic center is 8.5 kpc away and the sun takes 250 million years to make one Galactic revolution. Use approximate values and powers of ten.

First, since I want the mass, I solve for the mass to get

$M = a^3 / P^2$. Next, I write $P = 2.5 \times 10^8$ yr, and convert a into AU knowing that 1 pc = 206,265 AU (see Appendix, page A2). I shall take approximately 1 pc = 2×10^5 AU. So $a = 8.5 \times 10^3 \times 2 \times 10^5$ AU = 17×10^8 AU = 1.7×10^9 AU. Now we can calculate the mass:

$M = 1.7^3 \times 10^{27} / 2.5^2 \times 10^{16}$ $M_\odot \approx 5/6 \times 10^{11}$ $M_\odot \approx 0.8 \times 10^{11}$ $M_\odot$

2) Many galaxies have flat rotation curves that extend well beyond the visible part of the galaxy. Since the orbital period is $P = 2\pi\, a/v_{rot}$, this period increases in direct proportion to a, if v_{rot} is constant. Supposing that the rotation velocity of our galaxy is still 220 km/s all the way out to 3x8.5 kpc, how much bigger would be the total mass out to that distance? HINT: DO NOT REPEAT THE PREVIOUS CALCULATION, INSTEAD USE PROPORTIONS.

The orbital period is directly proportional to a, for constant v_{rot}.
The mass is therefore proportional to $a^3/a^2 = a$.
So tripling a results in tripling the mass.