

Astronomy 160b — spring 2007
Problem Set #7 — due April 12 in class

I (10 points). Suppose the density of the universe is exactly equal to the critical density (with $H = 70\text{km/s/Mpc}$), and all the matter is contained within identical galaxies, one per cubic megaparsec.

- a) Determine the mass of each galaxy.
- b) Most stars are a little bit less massive than the Sun, but a lot less bright. Suppose an average solar mass of material in these galaxies generates only 1/10 the brightness of the Sun, calculate the apparent magnitude of the nearest such galaxy (at a distance of 1 Mpc).
- c) Suppose you observe a star orbiting around one of these galaxies, 30 kiloparsecs away from the center of the galaxy. How fast would it be moving (for purposes of this problem you can assume that essentially *all* the mass of the galaxy is contained within 30 kiloparsecs of the center).

II (10 points). One of the main opponents of the Big Bang theory is an observational astronomer named Halton Arp. Arp is a specialist in observing odd-looking galaxies — his catalog of strange galaxies is still in use. Arp claims that the redshifts of quasars are *not* due to the expansion of the universe (perhaps they might be caused by gravitational redshift in some way). His primary observational evidence for this claim is that some high-redshift quasars are very close to low-redshift galaxies — he claims that this means they are in fact the same objects, located at the redshift of the galaxy. There's more information available on Arp and his claims from a link on the course website, or directly at <http://www.astro.yale.edu/bailyn/astro160/arp.html>

- a) Explain why the claim that the high redshifts of quasars are *not* due to the expansion of the Universe undermines support for the Big Bang.
- b) Suggest a way (or ways) in which Arp's claims could be tested. (Extra credit for pointing to one or more specific examples of tests that have been carried out).
- c) For over two decades, Arp's proposals to investigate the so-called "bridges" from high-redshift quasars to low redshift galaxies have generally been turned down by telescope time-allocation committees. Is this justified? Keep in mind that Arp has had a *very* distinguished career as an observational astronomer — should that make a difference? In general, does it make sense to reserve some resources for "high-risk" projects? On what basis should such proposals be evaluated? Would the project(s) described in your answer to (b) and/or Arp's "bridge" observations be a good use of such a reserve?