Astronomy 160: Frontiers and Controversies in Astrophysics

Homework Set # 9 Solutions

1) **Some preliminary exercises in dealing with BCGs:**

a) **Assuming that the light from a BCG is made up of light from stars like the Sun, how many stars does a BCG contain? Recall that the absolute magnitude of the Sun is +5.**

We can compare the absolute magnitude of the Sun to the absolute magnitude of a BCG in order to find the ratio of their luminosities. We can do this via the magnitude equation:

$$\begin{aligned}
M_{\rm BCG} - M_\odot &= -2.5 \log \frac{L_{\rm BCG}}{L_\odot} \\
-25 - 5 &= -2.5 \log \frac{L_{\rm BCG}}{L_\odot} \\
-30 &= -2.5 \log \frac{L_{\rm BCG}}{L_\odot} \\
12 &= \log \frac{L_{\rm BCG}}{L_\odot} \\
10^{12} &= \frac{L_{\rm BCG}}{L_\odot}
\end{aligned}$$

This means that the BCG is 10^{12} times more luminous than the Sun. Assuming that all of the stars in the BCG are like the Sun, this means that there must be 10^{12} Sun-like stars in the BCG.

b) **If a BCG is observed to have an apparent magnitude of 10, what is its redshift z?**

The redshift of an object is just an effect of the object moving away from us. We know that the velocity that an object is receding from us in the Hubble flow is proportional to its distance by the equation $v = Hd$. So, in order to find its redshift, we first need to find its distance. Since we have both the apparent and absolute magnitudes, we can use the distance modulus equation to find the distance:

$$\begin{aligned}
m - M &= 5 \log (d/10\text{pc}) \\
10 - (-25) &= 5 \log (d/10\text{pc}) \\
35 &= 5 \log (d/10\text{pc}) \\
7 &= \log (d/10\text{pc}) \\
10^7 &= d/10\text{pc} \\
d &= 10^8\text{pc} = 10^2\text{Mpc}
\end{aligned}$$

Now, we can plug this in to the Hubble equation:

$$\begin{aligned} v &= Hd \\ &= 70 \text{ km/s/Mpc} \times 10^2 \text{Mpc} \\ &= 7 \times 10^3 \text{km/s} \end{aligned}$$

This is much smaller than the speed of light, so we can use the non-relativistic equation for z:

$$\begin{aligned} z &= \frac{v}{c} \\ &= \frac{7 \times 10^3 \text{km/s}}{3 \times 10^5 \text{km/s}} \\ &= 2 \times 10^{-2} = 0.02 \end{aligned}$$

2) a) **Explain why this would be a serious problem for using BCGs for studying cosmology.**

In order to use BGCs as standard candles, we have to know their absolute magnitudes (or brightnesses). Since the mass (and therefore the brightness) of BGCs changes with time, they cannot serve as reliable standard candles.

b) **Suppose the observed magnitudes and redshifts of BCGs agreed with Type Ia supernovae out to $z = 1$, but when observed further away (out to $z = 2$ or so) implied a "Big Rip" cosmology. Explain why the problem noted above would** *not* be able to explain this result.

Young BGCs (high Z) are fainter, as they have not yet accumulated all of their mass. In a Big Rip cosmology, higher Z objects will look **brighter**, not fainter.

3) a) **Suppose the financial resources only existed to support one of these two projects. Based on the information on the websites, and links from the websites, which of the two would you support, and why?**

Contrast the scientific goals of LSST and SNAP; specifically, the different redshift ranges each project will be looking at. What do you gain by funding one project that you would lose by not funding the other one? I was also looking for a discussion of the feasibility (and risk) of the projects – this could be related to the large amounts of data that LSST will be creating every night.

b) **Funding agencies are very enthusiastic these days about web sites that are educational to the public. In terms of communicating science to the educated public (that's you) give each of these two sites a grade of 1-5 (1=poor, 5=excellent), describe their strengths and weaknesses, suggest**

ways they might be improved.

There is no right answer to this question. I wanted to see a numerical grade for each website and then several (at least 3 well thought out) justifications.