

# Homework 1

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## 1. Problem 1

Please see “expr.txt” for detail.

## 2. Problem 2

The original data is cleaned and reshaped into four columns using shell commands. The final format of the columns is:

- Recession velocity (km/s)
- Polar angle  $\theta$
- Azimuthal angle  $\phi$
- Absolute Magnitude

respectively.

### (a) Searching for the galaxy with smallest and largest velocity

This is achieved mainly via “sort -n” command in bash. Sorting by first column will immediately yield the result. To take the galaxy with smallest velocity, I used “head -1” while for the largest one, “tail -1”.

The smallest velocity is:

$$v_m = 3734\text{km/s}$$

and the largest one is

$$v_M = 78736\text{km/s}$$

For the complete result, please refer to *smallest\_velo.txt* and *largest\_velo.txt*

### (b) Recession velocities of the brightest and faintest galaxies

This task is basically the same to the former one while the sorting is Absolute Magnitude. This is simple in bash. The “sort -n -k 4” will do everything.

Noticing that the brightest galaxy has the most negative absolute magnitude, “head -1” will sieve it out. For the same reason “tail -1” gives the faintest galaxy.

The velocity of brightest galaxy is

$$v_b = 54610 \text{ km/s}$$

and that of the faintest one is

$$v_f = 3734 \text{ km/s}$$

The complete result is in *brightest.txt* and *faintest.txt*

(c) Threshold magnitude criteria

galaxies should be brighter than a certain threshold and can be detected by a observatory. Now we are verifying the data we filtered from. Problem 2(b).

Literature on the internet often measures the brightness in apparent magnitude. We shall convert the absolute magnitude into the apparent one. They are related by the following formula

$$m - M = 5 (\log_{10} d - 1)$$

or

$$m = M + 5 (\log_{10} d - 1) \quad (1)$$

where  $m$  denotes the apparent magnitude and  $M$  the absolute one.  $d$  represents the distance which can be calculated by

$$d = \frac{v}{H_0} \quad (2)$$

$v$  in Equation 2 is the recession velocity of a galaxy and  $H_0$  is Hubble constant. Substitute Equation 2 in Equation 1 we get the estimated apparent magnitude after some manipulation on the dimensions.

$$m \approx 6$$

This is roughly the typical limit of naked eye[1]. Therefore our data is **consistent** with this fact

The *galaxies.txt* contains the data selected for parts a and b. The rows are record of slowest fastest brightest and faintest galaxies and the columns are the same as original meaning.

**Run the *run.sh* and you will get the answer for Problem 2**

## References

- [1] [https://en.wikipedia.org/wiki/Magnitude\\_%28astronomy%29#Apparent\\_magnitude](https://en.wikipedia.org/wiki/Magnitude_%28astronomy%29#Apparent_magnitude)