Galactic and Extragalactic Astronomy Sheet 1

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1 Exercise 1

1.1 Redshift

Reading from the graph the measured $Lyman-\alpha$ line of the Andromeda Galaxy is at $121.3nm$ however it shoud be at $121.5nm$. Therefore the redshift

$$z = \frac{\Delta\lambda}{\lambda_0} = -1.64 * 10^{-3} \tag{1}$$

Wich is connected to the radial velocity according to

$$1 + z = \sqrt{\frac{1 + \frac{v}{c}}{1 - \frac{v}{c}}} \tag{2}$$

and therefore

$$v = c\frac{(z+1)^2 - 1}{(z+1)^2 + 1} \tag{3}$$

$$\implies v = 0.0016c \tag{4}$$

1.2 Hubble flow

The Andromeda Galaxy is Gravitationally bound to our Galaxy and therefore independent of the Hubble flow . The Hubble flow is moving away from us, Andromeda however is traveling towards us. The Hubble flow of Andromeda would be :

$$v = 5.5 * 10^4 = 0.00018c$$

1.3 Distant Galaxies

According to eqation 3 the Galaxy is moving with

$$v = 0.049c$$

and is therefore at

$$D = 207Mpc$$

2 Exercise 2

2.1 Matter Annihilation

The reaction freezes out at slightly less than

$$T = 1022keV \approx 10^{10}K$$

since this is equal to the rest masses of the Electron and Positron. Since it is always a Temperature spectrum the freezout happens slightly after the average Temperature drops under the minimum energy needed for a pair production.

2.2 Photon Temperature

2.3 D Binding

The bindingenergy for Deuterium is

$$E_b = 2.2MeV$$

Therefore a Photon with this Energy can destroy a Deuterium Atom. Since this is the lowest binding energy a nukleus can have it gets easily distroyed and therefore is quite rare to survive the early Universe. A photon with being able to distroy such a Deuterium nukleus has to have at least the frequency

$$\nu = \frac{E_b}{h} = 3.3310^9 Hz$$