Intergalactic Hydrogen and Spectrum of Quasars and Galaxies

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Abstract

Author present the calculation of the absorption cross section by Lyman alpha line depending on the concentration of neutral hydrogen in intergalactic medium (IGM), different from the calculation, proposed by J. Gunn and B.Peterson in [1]. The method proposed by Y. B. Zel'dovich and Y. P. Rajzer in [2] serves as a basis for calculation. The calculation shows that the concentration of neutral hydrogen in the IGM can reach 10 $^{-3}$ cm^{3} and more, in this case the Gunn-Peterson effect will not be observed. The probable mechanism of "blueing" of the galaxies spectrum is examined.

Let us consider infinite, stationary and homogeneous universe (for example [3], [4] where the red shift and time dilation are explained without the theory of the Big Bang and the cosmological constant is equal to zero with metric (for each observer at each point of space):

$$ds^2=-c^2\cdot (1+ k_1\cdot z)^2\cdot dt^2 + (1/(1+ k_2\cdot z)^2)\cdot dr^2 +r^2(d\theta^2+\sin^2\theta d\varphi^2) \qquad (1)$$

where z - red shift, k_1 and k_2 - certain factors (for small z equal to 1 functions in general cases)

Accept, there is a source of emission (Source) at a distance, corresponding to z = 1 (~ 10 billion of light years) from the observer (Observer). The Source emits light with a wavelength of λ = 810,6Å. The space between the Source and the Observer is filled with neutral hydrogen. Let us consider absorption of emission by neutral hydrogen on the Lyman alpha line ($L\alpha$ = 1216Å). Due to the red shift absorption will occur at a distance of appropriate z = 0.5 from the Source.

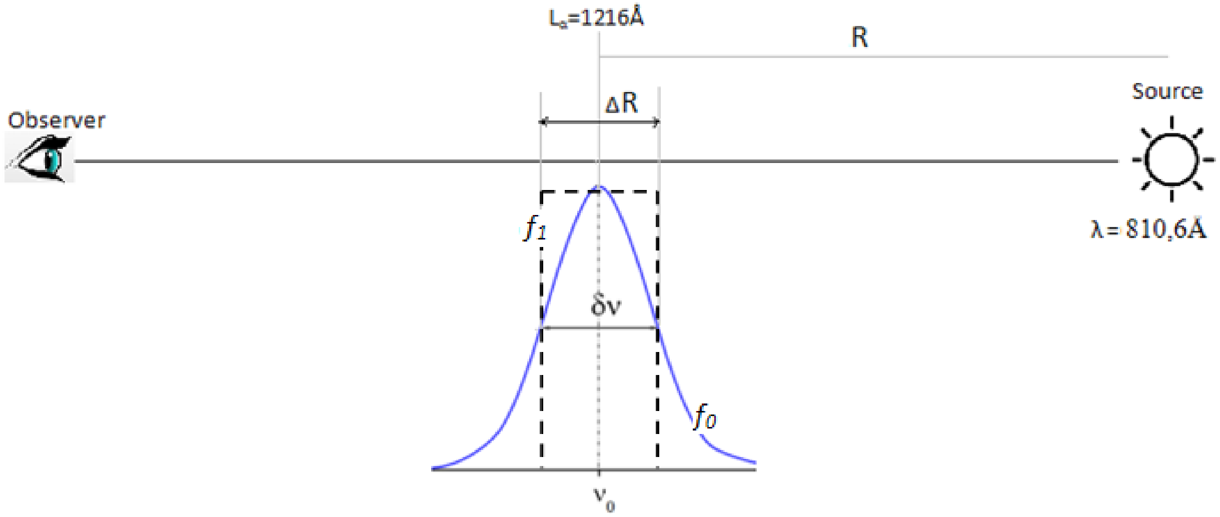

Fig.1

We use the method set out by Ya. B. Zel'dovich and Yu. P. Rajzer [1] (Chapter V, §9) to estimate the absorption cross section. They result the value and distribution of the effective absorption cross section for the natural linewidth (Fig.1). At the effects of line broadening, in particular Doppler's one, line width increases at higher temperatures, but at the same, maximum value (absorption cross section at the line center) of the bell function $f1$ decreases and the summary cross section remains constant and in our case it does not affect the result. Therefore, we confine ourselves to consideration of the absorption for the natural width of the line. To estimate the summary value of the absorption cross section (rough estimate) we can replace the bell-shaped distribution (the function f_0) of the section with rectangular (dashed line - the function f_1) and calculate the absorption for the function f_1. In [1] values of the widths are given: $\Delta\lambda = (c\cdot\Delta\nu)/\nu_0^2$ = 1,2·10^{-4} Å (1,2·10^{-12} cm); and of the maximum cross section $\sigma_{\nu\ max} = \lambda^2\cdot 3/2\pi$ (for L_α=1216Å : $\sigma_{\nu 0\ max}$ = (1.2·10^{-5} cm)^2 ·3/3.14 = 1.37·10^{-10} cm^2). The frequency linewidth $\delta\nu = c/\lambda$ = 3*10^{-4} sec^{-1}. Alteration z: $\Delta z = \delta\nu/\nu_0$= 3*10^{-4}/2.5*10^{15} =10^{-19}, that corresponds to the distance $\Delta R = c\cdot\Delta z/H$ =3*10^{10}*10^{-19} /2,3·10^{-18} s^{-1} = 10^9 cm. Summary absorption cross section of all the atoms in a column of gas with the area of 1 cm^2 and with a length of ΔR results as

$$\sigma_s = \sigma_{\nu 0\ max}\cdot N\cdot\Delta R \qquad (2)$$

At a concentration of N =10^{-3} cm^3, ΔR= 10^9 cm, σ_o = 10^{-10} cm^2,σ_s = 3*10^{-4} cm^2, i.e. about 0.1% of the photons will be absorbed, that cannot provide any appreciable absorption and especially it will be not enough to exhibit the Gunn-Peterson effect.

Accept, occupation density of the upper (IR) levels (series of Paschen, Brekkett etc.) is high (similar to recombination radio lines in HII zones). A possible reason for this may be the emission spectrum that passes through intergalactic hydrogen and that differs substantially of the emission spectrum that passes through the hydrogen in the galaxy (prevalence of infrared and microwave emission)(M.Longeyr R.Syunyaev, 1971)). Such spectrum can be explained by the fact that (when a large part of the emission is emission of galaxies like our own) the number of light sources increases in proportion to the square of the distance and the number of photons from each source decreases inversely proportional to the same square, but the frequency of the photons decreases in proportion to z.

Let us consider the absorption of emission by neutral hydrogen in the two lines with the wavelengths of λ_{10}=400 nm and λ_{20}=740 nm (blue and red light) from the Source located at a distance corresponding to z = 4 from the Observer. Due to the red shift, wave length of the line λ_{10}=400 nm for an Observer becomes λ_{11}=2000 nm. I.e. the photons with λ_{10}=400 nm will pass successively through the absorption lines from the Balmer line Ba-δ (n_1 = 2, n_2=6) to the Brackett line (n_1 = 5, n_2=8), approximately through 74 of the absorption lines. Wave length of the line λ_{20}=740 nm becomes λ_{21}=3700 nm. And the photons with λ_{20}=740 nm will pass successively through the absorption lines from the Paschen series to the Humphreys line (n_1 = 6, n_2=17), approximately through 122 of the absorption lines. Figure 2 shows the dependence of number of absorption lines through which the photons pass from the wavelength of the emission Source at different z. General regularity - the number of lines of absorption (and absorption) increases with increasing of wavelength and with increasing of z.

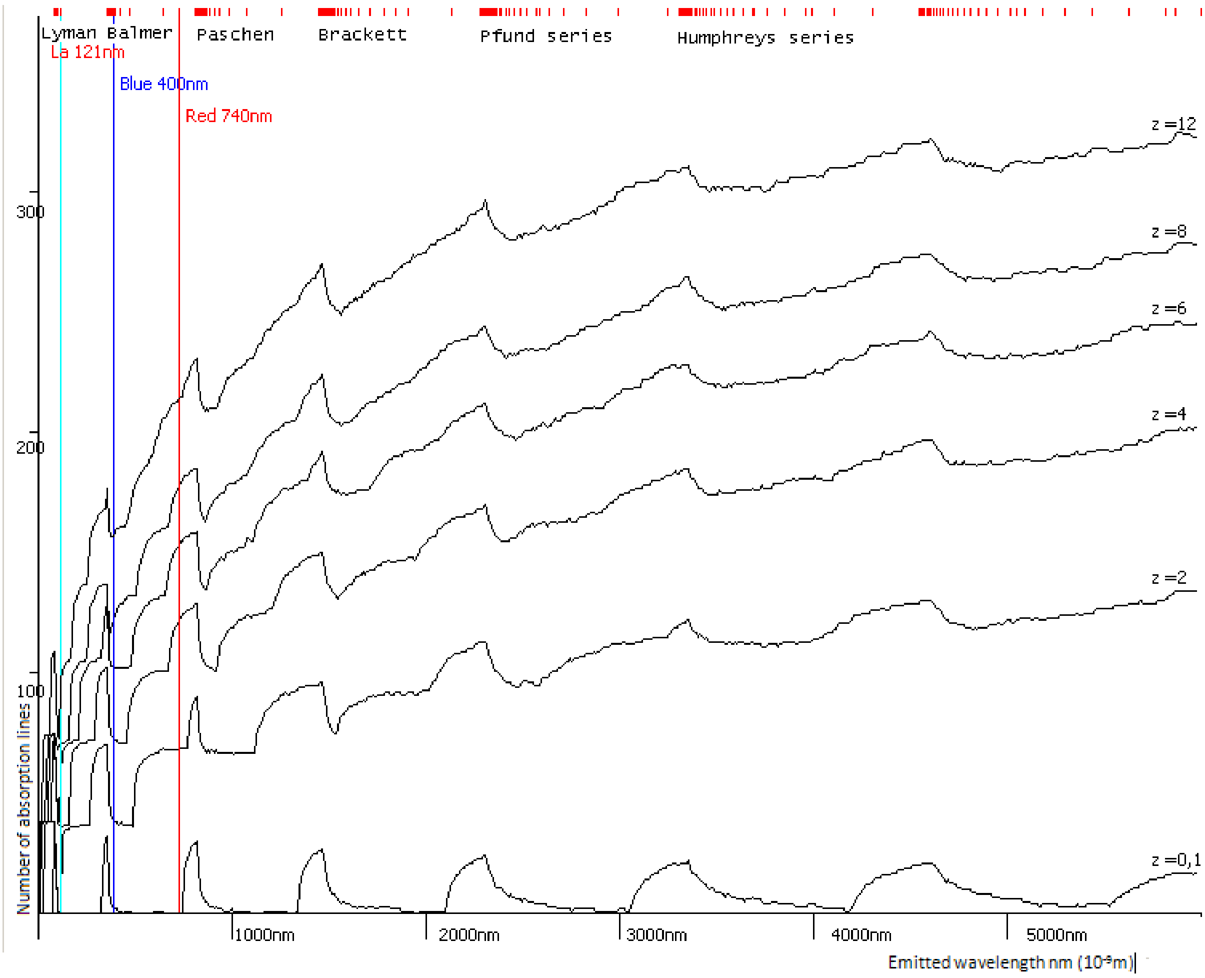

Fig.2 Dependence of number of the absorption lines of the wavelength of emission at different z. (Computer program with a maximum n_1 = 40)

To calculate the factors (cross sections) of absorption you need to know more precisely the occupation density of levels of intergalactic gas, its concentration (which generally may vary quite widely), the absorption factor at all levels (that will slightly change the shape of the curves in Fig.2 depending on n_1 and n_2), taking into account the influence of other gases (helium, etc.)

But in general, qualitatively, graphs in Figure 2 explain:

- displacement of the intensity of the galaxies spectrum with increasing z into the region of shorter wavelengths ("young" or "blue" galaxies)
- decrease in intensity of the emission power of galaxies at large (> 7) z (dwarf galaxies)
- spectrum at very large z that degenerates into a single line (lines).

It is also necessary to take into account the Thomson scattering that becomes significant for distances z = 1. And for large z we see mostly reflected light, thanks to that there is a high probability of a small-angle scattering. Summary intensity consists of many scattered photons that pass different distances, whereupon they have various red shifts that slightly differ from the red shifts in a straight line. Consequently, all sharp peaks (in particular, metal lines) of the spectrum blur out and disappear.

Additionally, we can note that in the infinite, stationary and homogeneous universe, the distance, passed by the light from z = 0 to z = 1(R_{z0}) is equal to the distance from z = 1 to z = 2 (Rz_1) and to the distance from z = 2 to z = 3 (Rz_2). Consequently, the volume between the spheres of radii Rz_2 and Rz_1 is 73 times greater than the volume of the ball, limited with the sphere of radius R_{z0}. This may explain that the bulk of observed quasars is located at a distance that corresponds to the red shift z> = 2.

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Reference:

1. J. E. Gunn and B. A. Peterson. On the Density of Neutral Hydrogen in Intergalactic Space. ApJ, 142:1633–1641, Nov. 1965.
2. Ya. B. Zel'dovich Yu. P. Raizer "Physics of Shock Waves and High-Temperature Hydrodynamic Phenomena" Volume I ACADEMIC PRESS New York and London 1967
3. Valery Zhukov, Redshift and the Curvature of Space. http://vixra.org/abs/1406.0021
4. Valery Zhukov, Cosmological Redshift and Gravitational Waves. http://vixra.org/abs/1410.0006