THE SPECTRUM DISTORTION OF RELIC RADIATION IN THE MOMENT OF UNIVERSE RECOMBINATION

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Matsumoto et al. (1988) have reported a significant distortion in the spectrum of microwave background radiation in the submillimetre waveband 400-700 μ. This follows a rocket experiment by a team from Nagoya and Berkeley in February, 1987. This experiment has resulted in a series of papers which have attempted to interpret this excess (see Carr, 1988). This result may force us to revise the process of universe recombination and/or to resort to nonequilibrium processes. The distortion of the cosmic microwave background radiation (CMB) from Planck spectrum may necessarily arise because of the production of energetic quanta in the process of recombination which lead to retarding former and distortion of CMB both in the Wein region and the Rayleigh-Jeans region (Zeldovich, Kurt, and Sunyaev, 1969; Lumbarskii and Sunyaev, 1983).

There are two types of explanation for the submillimetre excess. First, the microwave photons could have interacted with hot electrons while passing through ionized intergalactic gas. The gas would need to have a temperature of about 10^8 K. The thermal bremsstrahlung radiation from such a gas has already been invoked to explain the hard X-ray background. However, the Compton distortion model fits the data only if the Rayleigh-Jeans temperature of the CMB is much smaller than usually assumed (Hayakawa et al., 1987). Second, the submillimetre excess may represent emission from cosmological dust, the dust itself having been heated by some radiation source. In this case, one can fit the observed distortion rather well (Bond, Carr, and Hogan, 1988). Both models face severe energetic demands. Alternatively, the radiation could be produced by decaying elementary particle relics of the Big Bang (Stebbins and Silk, 1986; Doroshkevich et al., 1989). Such particles (or their decay products) are often invoked as candidates for dark matter.

Lumbarskii and Sunyaev (1983) noticed that the recombination is nonequilibrium process. For determination of cosmic background distortions of spectrum in cosmological expansion, it is necessary to consider the process transfer of radiation (Peebles, 1968):

$$N \frac{\partial}{\partial t} \left[\frac{I_\omega}{N} \right] - \frac{\omega}{a} \frac{da}{dt} \frac{\partial I_\omega}{\partial \omega} = St(I_\omega) \tag{1}$$

Here N is the concentration of H-atoms and protons, I_ω is the spectral intensity, a is the cosmological scale length, and $St(I_\omega)$ is the functional determinative the change of photons for interaction with matter. $I_\omega(0) = I_\omega^o$ is Planck spectrum with T_0.

$$St(I_\omega) = c\ (Q_\omega^{Br} + Q_\omega^{Phr}) - c\ I_\omega\ (K_\omega^{Ba} + K_\omega^{Pha}) + St^{TS} + St^{Lr} \tag{2}$$

Here Q_ω^{Br} is the source of bremmstrahlung radiation, Q_ω^{Phr} is the source of photorecombinational radiation, K_ω^{Ba} is the coefficient of Bremmstrahlung absorption, and K_ω^{Pha} is the coefficient of absorption because of photoionization and induce photorecombination.

$$K_\omega^{Pha} = \sum_{m=1}^{\infty} \theta\ (\hbar\omega - \mathrm{E}_m)\ (\sigma_\omega^{im} N_m - \sigma_\omega^{m_i} N_i) \tag{3}$$

Here m is the number of level, N_m is the population m-level, N_i is the concentration of protons, $E_m = Ry/m^2$ is the energy of bound with m-level, $\theta(x)$ is the function of Heaveyside, σ_ω^{im} is the section of photoionization with m-level, $\sigma_\omega^{m_i}$ is the section of induce photorecombination on m-level, and

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$$St^{Lr} = c \sum_{m'=2}^{\infty} \sum_{m=1}^{m'-1} [\hbar\omega\, A_{mm'}\, S_{\omega}^{mm'}\, N_{m'} - I_{\omega}\, (\sigma_{\omega}^{m'm}\, N_m - \sigma^{mm'}\, N_{m'})] \tag{4}$$

is the functional determinative the change of number of photons because of the radiation and absorption in lines. Here $A_{mm'}$ is the rate of spontaneous decay of $m' \rightarrow m$, $S_{\omega}^{mm'}$ is the spectral function on the transition $m' \rightarrow m$ $\sigma_{\omega}^{m'm}$ is the section of photoexcitation, and $\sigma_{\omega}^{mm'}$ is the section of induce spontaneous decay.

It is suggested the expanding universe is the isotropic and the homogeneous because the equations of transitting processes in moment of recombination determining the charge and the energetic balance are local. The equations of balance of energy (Derzhiev et al., 1986) are

$$3/2\, N\frac{d}{dt}\left[\frac{N_e}{N} T_e\right] - T_e \frac{N_e}{N}\frac{dN}{dt} = -Q_i + \int_o^{\infty} d\omega\, (K_{\omega}^{Ba} I_{\omega} - Q_{\omega}^{Ba}) + \tag{5}$$

$$\sum_{m=1}^{\infty} \int_{E_m}^{\infty} d\omega (\hbar\omega - E_m)\, \frac{I_{\omega}}{\hbar\omega}\, (\sigma_{\omega}^{im}\, N_m - \sigma_{\omega}^{mi}\, N_i) + Q_{ep},$$

where the terminology follows Derzhiev et al. (1986).

The initial conditions are: $T(0) = T_e(0) = T_o$. The equations of kinetics are written

$$N\frac{d}{dt} N_i \left[\frac{N_i}{N}\right] = \sum_{m=1}^{\infty} \left[V_{im}\, N_e + \int_{E_m}^{\infty} d\omega\, \frac{I_{\omega}}{\hbar\omega}\, \sigma_{\omega}^{im}\right] N_m - \sum_{m=1}^{\infty} \left[C_{mi}\, N_e^2 + R_{mi}\, N_e + \int_{E_m}^{\infty} d\omega\, \frac{I_{\omega}}{\hbar\omega}\, \sigma_{\omega}^{mi}\right] N_i \tag{6}$$

$$N\frac{d}{dt}\left[\frac{N_m}{N}\right] = \left[C_{mi}\, N_e^2 + R_{mi}\, N_e + \int_{E_m}^{\infty} d\omega \frac{I_{\omega}}{\hbar\omega} \sigma_{\omega}^{mi}\right] N_i -$$

$$\left[V_{im}\, N_e + \int_{E_m}^{\infty} d\omega \frac{I_{\omega}}{\hbar\omega}\, \sigma_{\omega}^{im}\right] N_m + \sum_{m'=1}^{m-1} \left[V_{mm'}\, N_e + \int_{o}^{\infty} d\omega \frac{I_{\omega}}{\hbar\omega} \sigma_{\omega}^{mm'}\right] N_{m'} - \tag{7}$$

$$\sum_{m'=1}^{m-1} \left[A_{m'm} + V_{m'm}\, N_e + \int_0^{\infty} d\omega \frac{I_{\omega}}{\hbar\omega}\, \sigma_{\omega}^{mm'}\right] N_m +$$

$$\sum_{m'=m+1}^{\infty} \left[A_{mm'} + V_{mm'}\, N_e + \int_0^{\infty} d\omega\, \frac{I\omega}{\hbar\omega} \sigma_{\omega}^{mm'}\right] N_{m'} - \sum_{m'=m+1}^{\infty} \left[V_{mm'}\, N_e + \int_o^{\infty} d\omega \frac{I_{\omega}}{\hbar\omega} \sigma_{\omega}^{m'm}\right] N_m.$$

The initial conditions are $N_i(0) = N(0)$; $N_m(0) = 0$.

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