JOURNAL OF THE KOREAN ASTRONOMICAL SOCIETY
29: S41 ~ S42, 1996

TWO POSSIBLE COSMIC X-RAY SPECTRAL LINES

XUEJUN WU AND CHONGMING XU
Department of Physics, Nanjing Normal University, Nanjing 210097, P.R.China

ABSTRACT

A possible cosmic X-ray background(XRB) radiation related to original antimatter is considered. If the universe is made of separating domains of antimatter and matter, the photons produced by the annihilation of electron-positron and proton-antiproton on the last scattering surface would reach us in the energy ~0.45 keV and ~60 keV respectively because of the redshift. The spectrums of X-ray radiation from annihilation are deduced and a possible observational figure is described also.

Key Words : X-ray background, Antimatter, Cosmology

I. INTRODUCTION

The X-ray background (XRB) radiation was first discovered by Giacconi et al. (Giacconi 1962). Since then, the whole band of XRB has been studied by means of HEAO-1,2 and ROSAT. The bulk of the energy density of the X-ray in the sky is dominated by a diffuse cosmic radiation caused by several models (Fabin 1992). In this paper we suggest that a part of XRB might be related to the original antimatter if a symmetric universe existed.

A complete symmetric universe was discussed by Dirac (Dirac 1933). The evolution from a symmetric universe to an asymmetric one was discussed by Sakharov (Sakharov 1967) in an acceptable way. Some scientists still believe in a symmetric universe (Ting 1995, Glashow 1995). The effort at studying the original antimatter from other clusters has never ceased (Stecker 1971; Balebanov 1994). Especially, the plan of "Alpha Magnetic Spectrometer (AMS)" (Ting 1995, Balebanov 1994) involving in more than 200 physicists from all over the world and headed by the Nobelist S.C.C.Ting is quite impressive.

In this paper, the starting point is based on the two acceptable facts: an expanding universe and the existence of the last scattering surface (LSS).

II. A POSSIBLE CONTRIBUTION OF ANNIHILATION AND SPECTRUM

For the annihilation of e^- and e^+ we have

$$e^+ + e^- \rightarrow \gamma + \gamma\,, \qquad (1)$$

where the photons $\gamma = 0.511$ MeV. Because of Thomson scattering effects the earliest photons produced by the annihilation, which could reach us, are formed on the LSS. We expect that the strongest annihilation of electrons and positrons on the border of two opposite domains occurred at the time of recombination. The photons produced by the annihilation of electrons and positrons on the LSS could be observed in the energy of 0.51 keV - 0.39 keV due to the redshift ($z \sim 1000 - 1300$). We take 0.45 keV as the arriving energy of the photon from the LSS.

The intensity I_l, which is the arriving number of photons in unit solid angular per second, can be deduced as

$$I_l \propto \frac{R(t)}{R(t)^{6+\alpha}} = \frac{1}{R(t)^{5+\alpha}} \propto \frac{1}{(h\nu_o)^{5+\alpha}}\,, \qquad (2)$$

where $h\nu_o$ is the energy of the received photon, $R(t)$ the scalar factor of the universe at the time t, α is a small quantity dependent on the contour of the border, the coefficient of diffusion and the ratio of annihilation of e^- and e^+.

The process of the annihilation of proton-antiproton is rather complicated for there are many possible procedures involved. Nevertheless, the π^0 have to be created and decay into two photons γ_{π^0} with the energy of 67.5 MeV. The same case as annihilation of electron-positron, We receive the energy of the photon γ_{π^0} from the LSS, which is then redshifted to about 60 keV and the spectrum is

$$I_h \propto \frac{1}{R(t)^{5+\beta}} \propto \frac{1}{(h\nu_o)^{5+\beta}}\,, \qquad (3)$$

where β is another function of time and spatial coordinates.

From above discussion we see, if the symmetric universe had existed, the two spectral lines of X-ray would have contributed to X-ray background radiation. The ratio of the energy of the two spectral lines is fixed at about 132, which is independent of any cosmological model and any intermediate process.

III. ESTIMATION OF OBSERVATION ON THE TWO POSSIBLE X-RAY SPECTRAL LINES

Since the data of observation on the cosmic ray rule out the possibility of the presence of large quantities of antimatter at least within the scale of 10 Mpc from the earth (Ting 1995), the size of the original antimatter domain should be larger than 20 Mpc now due to

the symmetric universe. On the LSS, it is corresponding to about an angular size of 12 arcmin. Since antimatter domain is enclosed by matter domains (or vice verse), a bright closed curve of the border surrounding the original antimatter domain could be seen. Because the total energy of the two possible spectral lines might contribute to a very small part of XRB, we think that the effective angular resolution of ROSAT is too low to clearly detect the signal from the border. The Advanced X-ray Astrophysics Facility (AXAF) (Seward 1996) scheduled to be launched by NASA next year can meet the requirement.

If we are able to use a very small angle (1 arcsec) detector to scan a big circle (straight line) in the sky, we might detect the peak of 0.45 keV and 60 keV in some points. Following these points we may draw a closed curve (the contour of the antimatter domain). If we could find out the bright X-ray closed curve in the energy we suggested, we could claim that the antimatter domain is discovered because the two sharp spectrumline with ratio of 132 would not mislead the existence of the antimatter domain.

If in such a small angle, we failed to find out any obvious suggested peak of the X-ray spectral line, we would doubt whether the antimatter domain really exists. In some sense, discovering the two possible X-ray spectral lines in a closed curve is equal to discover the original antimatter domains.

ACKNOWLEDGEMENTS

We thank Prof. Lu Tan for his useful discussion. This work was supported by the National Natural Science Foundation of China and Jiangsu province's Natural Science Foundation.

REFERENCES

Balebanov V.M., Ting S.C.C. et al., 1994, Nucl. Instrum. Methods Phys. Res. A., 350, 351.

Dirac P.A.M., 1933, Nobel lecture.

Fabin A.C., Barcons X., 1992, Annu. Rev. Astron. Astrophys., 30, 429.

Giacconi R., Gursky H., Paolini F. and Rossi B., 1962, Phys. Rev. Lett., 9, 439.

Glashow S., 1995, Lecture in Nanjing University.

Lund N. and Rotenberg M., 1986, A&A, 164, 231.

Sakharov A.D., 1967, Zh. Exp. Theor. Fiz., 5, 32.

Seward F., 1996, ASC Home page (fds@ofa.harvard.edu).

Stecker F.W., Morgan D.L.Jr. and Bredekamp J., 1971, Phys. Rev. Lett., 27, 1469.

Ting S.C.C., 1995, Proceeding of First International Conference on Frontiers of Physics (Shantou, China, Aug. 5-9 1995), Singapore, World Scientific (1996).