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SOME EVIDENCE FOR LARGE GRAVITATIONAL REDSHIFT IN SEYFERT GALAXY NGC 4151

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ABSTRACT

The photon spectra of two Seyfert galaxies NGC 4151 and MCG 8-11-11 are good experimentally established in the X-ray and gamma range.

In this paper we propose the annihilation of the high temperature positrons with cold electrons as the possible mechanism of photons productions in the Seyfert galaxy NGC 4151. The photon spectrum of NGC 4151 with whole its observed features from the soft X to the gamma ray range can be very good described by annihilation of positrons and electrons at temperatures $3 \cdot 10^{12}$ ^{o}K and 10^{8} ^{o}K respectively. Moreover the photon spectra from annihilation of unthermalized plasma with above parameters should be shifted to the lower energy by redshift $z = 100$. In that case the source of photons should be placed closely to the black hole horizon ($r = 1.0001\ r_g$).

1. INTRODUCTION

At the present time is quite clear that the pair (e^+,e^-) annihilation process occurs in certain classes of astrophysical objects. The positron-electron annihilation radiation is observed as well as the line 0.511 MeV from the Galactic Center (MacCallum and Le - venthal, 1983) and in gamma - ray bursts (Mazets et al., 1981). In a hot plasma the pairs are produced through: i) photon-photon, ii) photon-particle, iii) photon or particle in a strong field (magnetic or gravitational), iv) particle-particle interactions. The created pairs annihilate into photons or participate in other photon and pair producing processes. The great theoretical effort has been recently put by Svensson (1983) into the understanding of this process in the midly relativistic plasma.

We have studied the pair (e^+,e^-) annihilation phenomena in relativistic plasma in order to evaluate the photon energy spectrum, for the case in which the electron and positrons have different temperatures ($T_{e^-} \neq T_{e^+}$). In this paper we propose the annihilation of the high temperature positrons with cold electrons as the possible mechanism of photons productions in Seyfert galaxy NGC 4151.

2. METHOD AND RESULTS

We have analyzed the pair annihilation from hot plasma using analytical and numerical methods. To determine the photons energy production spectra from pair e^+,e^- annihilation, we assume that: i) angular momentum distributions of electrons and positrons are isotropic, ii) momentum distributions of electrons and positrons are Maxwellian with $T_{e^+} \neq T_{e^-}$. We have calculated the photons spectra for the temperature of electrons and positrons in the range 10^5 - 10^{13} K. Figure 1 shows as example the photons energy production spectra from annihilation process for the selected temperatures and unit concentration of positrons and electrons in the plasma. We can notice that the spectra have the characteristic power-low feature in central part, where the power index can be even $\alpha = -1$. We see also thermal cut-off from low and high energy sides. The photon spectrum of Seyfert galaxy NGC 4151 have a similar features, but in the low energy range (1 keV - 3 MeV). The photon spectrum of NGC 4151 in energy range from soft X-ray to 3 MeV is a power-low type but the spectral index is varing from -1.6 for HEAO 1/A4 X-ray measurements (Baity et al., 1983) to -1 for MISO gamma observations (Perotti et al., 1981 and 1983). Recently the obseved cut-off in the soft X-ray range was interpreted as photoabsorption or absorption

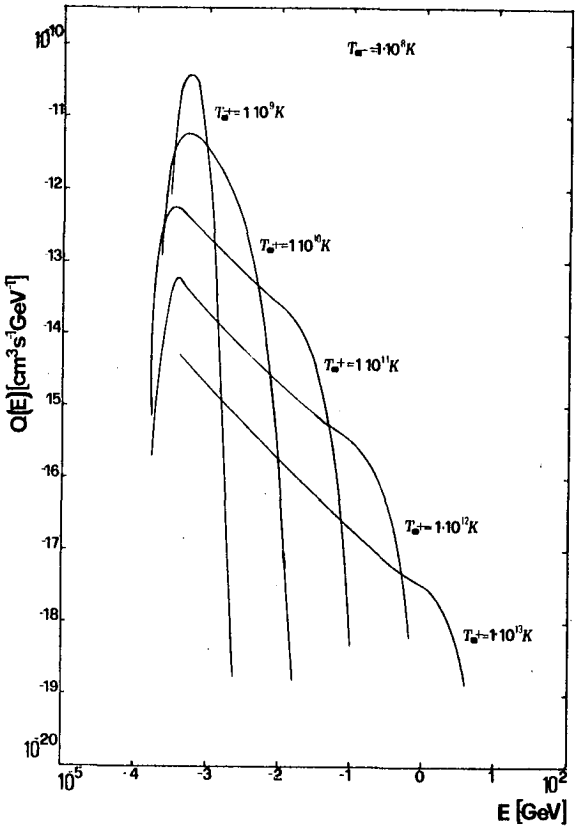

Fig. 1. The photons productions energy spectra from annihilation of the electrons with temperature $T_{e^-}=10^8$K and positrons with temperatures $T_{e^+}=10^8$, 10^9, 10^{10}, 10^{11}, 10^{12}, 10^{13}K respectively.

in the strong magnetic field. Many models have been proposed to explaining the spectral break at (1-3) MeV, for details see review paper Bassani et al. (1984).In this paper we propose the annihilation of high temperature positrons with cold electrons as the possible mechanism of photons productions in the Seyfert galaxy NGC 4151. The photon spectrum NGC 4151 with whole its observed features from the soft X-ray to the gamma-ray range can be good described by annihilations of positrons and electrons at temperatures $3 \cdot 10^{12}$K and 10^{8}K respectively. Moreover the photon spectra from annihilation of unthermalized plasma with above parameters should be shifted to the lower energy by redshift z = 100. We proposed black hole model for galactic nuclei with unthermalized electron-positron plasma in central region. The annihilation spectrum is shifted to the lower energy due to gravitational redshift. In that case the source of photons should be placed closely to the black hole horizon ($r=1.0001\ r_g$). Fig. 2 shows the photon spectrum of NGC 4151 obtained by different experiments taken from Houston and Wolfendale (1982). The full line shows the predicted flux from our model for parameters described above. The better estimation of discussed parameters will make possible from future simultaneous measurements of flux in X and gamma-ray energy ranges.

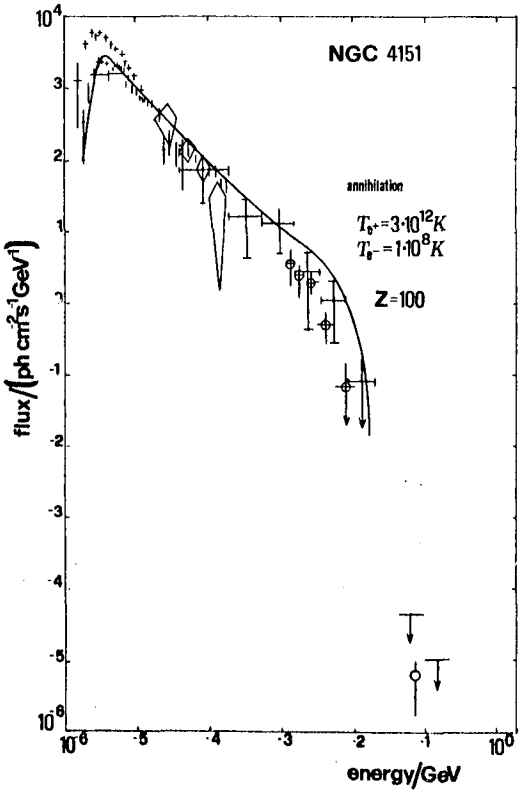

Fig. 2. Photon spectrum of NGC 4151 (from Houston and Wolfendale (1982)). The full line describes the redshifted by z = 100 spectrum from annihilation of electrons with temperature 10^{8} K and positrons with temperature $3 \cdot 10^{12}$ K.

3. DISCUSSION AND CONCLUSIONS

The photon spectrum of NGC 4151 in X and gamma energy range can be good described by the annihilation of hot positrons ($T_{e^+} = 3 \cdot 10^{12}$ K) with cold electrons ($T_{e^-} = 10^8$ K), moreover the annihilation region should be located closely to the black hole horizon ($r=1.0001\ r_g$). The concentration of electrons and positrons $n_{e^\pm} = 6 \cdot 10^{13}$ cm^{-3} in the central source ensures the observed flux from NGC 4151 in the case when it is the black hole with mass $10^9\ M_\odot$ in the nucleus and located at the distance of 20 Mpc. For the source of high temperature positrons ($T_{e^+} \quad T_{e^-}$), we propose two possible scenario: i) additional acceleration by the electric field, caused by charge separation, similar as we proposed for gamma bursts sources (Tkaczyk and Karakuła, 1985), ii) decay of secondaries π^+ from p-p interactions (Giovannelli et al., 1983a,b).

The timescale of flux variability expected from our model should be the same for diffrent energy ranges (X, gamma) and shorter than it is observed now. The simultaneous obsevations in the X and gamma ray ranges can support or exclude this model.

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