HIGH ENERGY GAMMA RAYS FROM ACCRETION DISC

F. Giovannelli
Istituto di Astrofisica Spaziale/CNR, Frascati, Italy
S. Karakula, W. Tkaczyk
Dept. of Physics, University of Lodz, Poland

In the case of spherical symmetric accretion into a black hole, the matter may be heated up to the temperature $KT = 0.1\ m_pc^2$ (Kolykhalov and Sunyaev, 1979). In such a hot plasma inelastic collisions of protons may produce Π° which is the gamma quantum source (Dahlbacka et al., 1974; Kolykhalov and Sunyaev, 1979).
In this work we determined γ-rays production spectrum in the comoving plasma reference frame, expected γ-rays spectrum for the case of spherica symmetric accretion of matter into a black hole and the upper limit to the number of black holes in Galaxy is evaluated.
In the calculations we made the following assumptions: 1) the plasma is fully ionized; 2) the proton momentum distribution is described by the relativistic Maxwell distribution; 3) the characteristics of interactions $p + p \rightarrow \Pi^\circ$ + anything were derived from an approximation of the experimental data (Barashenkov et al., 1972).
Fig. 1 shows the γ-rays production energy spectrum in the comoving plasma reference frame.
To evaluate the temperature, concentration and velocity of the plasma near a black hole, the system of equations describing the plasma motion should be solved (Michel, 1972)

$$\left(\frac{x}{x-1}\,\Theta + 1\right)^2\left(1 - \frac{1}{r} + u^2\right) = \text{const},\quad nur^2 = \text{const},\quad \frac{\Theta}{n^{x-1}} = \text{const},$$

where: $\Theta = KT/m_pc^2$, n - temperature and concentration of plasma in its own reference system, $r = R/R_g$, R - distance from black hole, R_g - its gravitation radius, u - R component of four velocity, $x = 5/3$.
To determine the temperature as a function of the distance from black hole, different values of u_o^2 were taken for given r_o. Calculations were done for $r_o = 10^4$, $u_o^2 = 2.6\ 10^{-5}$ and $6\ 10^{-6}$ corresponding to Mach numbers 1.0266 and 2.1213, respectively.
Fig. 2 shows expected energy spectrum $Q(E)$ from accretion disk multiplied by $R_g/\dot{M}^2$ ($\dot{M}$ - accretion rate) which is determined in Schwarzschild metric with regard to relativistic effects (curves a, b - for $u_o^2 = 2.6\ 10^{-5}$ and $6\ 10^{-5}$, respectively).
Assuming the black hole mass equal $10\ M_\odot$ and accretion rate $\dot{M} = 10^{-8} M_\odot$/year,we found its luminosity $L(E > 100\ \text{MeV})$ and emissivity $N(E > 100\ \text{MeV})$

G. Setti, G. Spada, and A. W. Wolfendale (eds.), Origin of Cosmic Rays, 335–336.

$L = 6.3\ 10^{33}$ erg/sec and $2.8\ 10^{32}$ erg/sec, $N = 2.1\ 10^{37}$ phot/sec and $7.3\ 10^{35}$ phot/sec for $u_o^2 = 2.6\ 10^{-5}$ and $6\ 10^{-5}$ respectively.

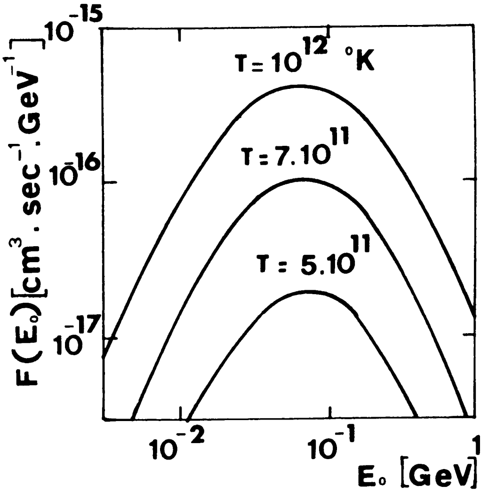

Fig. 1. The γ-rays production spectrum in the comoving plasma system.

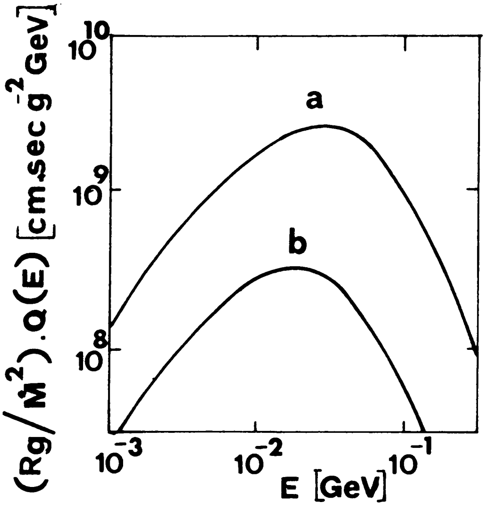

Fig. 2. The expected energy spectrum Q(E) from accretion disc multiplied by $R_g/\dot{M}^2$.

From the experimental measurements SAS-II, Galaxy emissivity of photons of energies E > 100 MeV is $1.3\ 10^{42}\ sec^{-1}$ (Strong et al., 1976). Assuming that all the Galaxy emissivity arises from considered objects, their number should be about 10^5 that gives 10^{-5} of the total star population. Taking into account another accretion parameter for instance $u_o^2 = 6\ 10^{-5}$ we derive the contribution of these objects of about 10^{-4}.
We conclude that such objects may give a significant contribution to the total emissivity of our Galaxy.

References

Kolykhalov, P.I., Sunyaev, R.A.: 1979, Soviet Astron. J. 56, 338

Dahlbacka, G.H. et al.: 1974, Nature 250, 36

Barashenkov, W.S. et al.: 1972, Vzajmodestvija vysokoenergeticeskih castic i atomnyh jader s jadrami, Moscow

Michel, F.C.: 1972, Astrophys. and Space Sci. 15, 153

Strong, A.W. et al.: 1976, Mon. Not. R. Astr. Soc. 175, 23P