A SELFCONSISTENT MULTIPLE COMPTON SCATTERING MODEL FOR THE X AND γ-RAY EMISSION FROM ACTIVE GALACTIC NUCLEI

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We refer to a model of active galactic nuclei where a massive black hole ($M \simeq 10^8 M_\odot$) is accreting spherically (1-3). Turbulent dissipation of the magnetic field produces an efficient heating. For low Thomson optical depth the main cooling mechanism is selfabsorbed cyclo-synchrotron (c-s) radiation from thermal electrons. The energy transfer of the thermal electrons to the c-s photons via Compton scattering (comptonization) becomes increasingly important for increasing optical depth. In ref. 2 the temperature profile of the inflowing gas was calculated balancing the heating and cooling mechanism but neglecting comptonization due to the difficulty of an analytic estimate of this process.

Extensive numerical computations by Pozdniakov, Sobol and Sunyaev (4) show that soft photons of energy $h\nu_s$, injected at the centre of a hot homogeneous sphere, emerge with a power law energy distribution from $h\nu_s$ to $h\nu$=3 kT, the spectral index of which is given by the approximate expression, valid also in the semirelativistic regime:

$$\alpha = \left\{-\lg\tau + 2/(n+3)\right\} \ / \ \lg\ (12\ n^2 + 25\ n) \tag{1}$$

where $n = kT/m_e c^2$.

Assuming that at each radius in the flow the spectral index $\alpha(r)$ can be evaluated from (1) with the optical depth and temperature at that radius, the Compton losses can be estimated integrating the power law normalized to the synchrotron flux at low frequencies up to $h\nu$ =3kT. This yields a Compton cooling rate

$$\Lambda_c = \frac{3}{r}\,\frac{2\pi kT}{(1-\alpha)c^2}\ \nu_s^{*\,(2+\alpha)}\left[\nu_{max}^{(1-\alpha)} - \nu_s^{*\,(1-\alpha)}\right] \tag{2}$$

with α given by (1). Here ν^* is the frequency at which the plasma becomes transparent to c-s radiation and ν_{max}=3kT/h. The determination of ν^* is one of the technical difficulties of the calculation, since in the semirelativistic regime a finite expression of the c-s absorption coefficient is not available.

In fig.1 the temperature profiles obtained with and without in-

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Table 1. M = black hole mass; Ṁ=accretion rate; τ =Thomson optical depth; L_{tot}=total luminosity; α =energy spectral index of Comptonized emission.

M (M_0)	Ṁ (g/s)	τ	L_{tot} erg s^{-1}	α
10^7	10^{23}	0.04	1.5×10^{43}	1.08
10^8	10^{24}	0.04	1.5×10^{44}	1.04
10^9	10^{25}	0.04	1.5×10^{45}	1.0
10^7	10^{24}	0.4	1.5×10^{44}	0.83
10^8	10^{25}	0.4	1.5×10^{45}	0.80
10^9	10^{26}	0.4	1.5×10^{46}	0.78
10^7	3×10^{24}	1.2	4.5×10^{44}	0.72
10^8	3×10^{25}	1.2	4.5×10^{45}	0.69
10^9	3×10^{26}	1.2	4.5×10^{46}	0.67

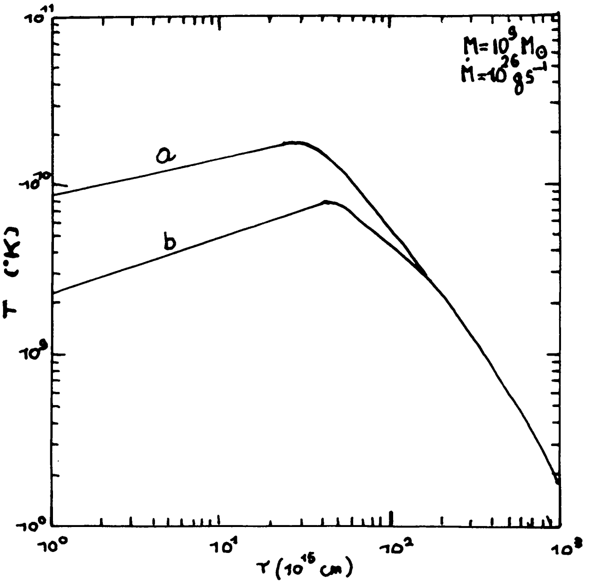

Fig.1. Temperature profile without (a) and with (b) comptonization losses.

clusion of comptonization are compared. In the cases examined the spectral index of the inner shells ($r \lesssim 30 r_s$) is practically constant and is given in Tab.1 for a range of parameters. The important result which is apparent from Tab.1 is that by varying the central mass and accretion rate by two orders of magnitude the spectral index is made to vary from 1 to 0.7. This can be understood as due to the strong dependence of the Compton cooling Λ_c on α and may represent a step in the explanation of the strong correlation of optical and X-ray luminosities in Seyfert galaxies and quasars (5,6).

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