Active Galactic Nuclei and Related Phenomena
IAU Symposium, Vol. 194, 1999
Yervant Terzian, Daniel Weedman, Edward Khachikian, eds.

Diffusion Mechanism of Radiation of a Charged Particle on the Randomly Spaced Dust Grains in the X-rays

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1. Diffusion radiation in the X-ray region

The theory of diffusion radiation of a charged particle on the fluctuations of the dielectric constant developed by Gevorkian can be explained as follows:

A charge moving in a medium creates an electromagnetic field (pseudophoton) which is scattered on the fluctuations of the dielectric constant (here, dust particles) and converted into radiation. In the wavelength region ($l \ll \lambda \ll L$) (l is the mean free path of the photon in the medium, L is the characteristic size of the system) the main mechanism of the radiation is the diffusion of the pseudophoton (Gevorkian & Atayan 1990, Gevorkian 1992, Gevorkian 1993).

For relativistic energies of charged particles ($\gamma > 10^3$) and characteristic sizes of dust particles ($a \sim 10^{-5} - 10^{-6}cm$), the characteristic frequency of diffusion radiation ($\omega_0 \sim \frac{c\gamma}{a}$) lies in the X- ray region. In this case, the intensity of diffusion radiation of one charged particle is given by (Gevorkian et al. 1998):

$$I^D(\omega) = 6\pi e^2 \frac{l_{in}(\omega)}{l^2(\omega)} \left(2 \ln \frac{c\gamma}{a\omega} - 1 \right) \tag{26}$$

where l_{in} is the inelastic mean free path:

$$l_{in} = \frac{1}{n_H \left(\sigma_H + \frac{\sum n_i \sigma_i}{n_i} \right)} \tag{27}$$

where n_H is the concentration of H atoms, σ_H is the photoionization cross section of H atoms , n_i and σ_i are concentration and cross section of the i-th element.

Thus the frequency dependence of l_{in} and I^D is determined by the frequency dependence of the photoeffect cross section. The elastic scattering mean free path is equal to:

$$l(\omega) = \frac{9\omega^2 c^2}{4\pi n a^4 \omega_p^4} \tag{28}$$

where n is the number density of dust particles, ω_p is plasma frequency.

The contribution of single scattering radiation is equal to (Gevorkian et al. 1998):

$$I^0(\omega) \approx 2\pi e^2 \frac{1}{l(\omega)} \left(2 \ln \frac{c\gamma}{a\omega} - 1 \right) . \tag{29}$$

Consequently, radiation emitted when charged particles pass through a dusty cloud could be much greater (by order of l_{in}/l) if one takes into account the diffusion term of radiation. We have estimated that in the range $2 - 10 keV$, l_{in}/l can be at least $10 - 100$. In dense dusty clouds l_{in}/l may reach up to 10^3.

Using photoionization cross sections calculated by Brown & Gould (1970) we have obtained the theoretical spectrum of diffusion radiation. The spectral index for the range $2 - 10 keV$ is equal to -0.8. In the general case, the expected indices lie in the range from -0.5 to -1.3 (Gevorkian et al. 1998).

2. AGNs as diffusion X - ray radiation sources?

A review of observational data obtained in the range $1 - 10 keV$ let us select AGNs as possible sources of X-ray diffusion radiation. The following observational evidence supports our selection:

- Extended X-ray emission (up to $1 Kpc$ in size) has been found around the nuclei of AGNs.
- In the nuclei of AGNs are all the necessary conditions (dust and relativistic electrons) for creating diffusion X-ray radiation. Most AGNs are a power source of IR and/or radio emission. There are some correlations between IR/radio and X-ray radiation. There is also a tight correlation between radio and X-ray morphologies.
- The spectral indices in $2 - 10 keV$ of an overwhelming majority of AGNs lie between -0.4 and -1.1 with the mean ~ -0.8.
- In the expected range of diffusion radiation ($\sim 1 - 10 keV$) observed spectra of AGNs often differ from the spectra of neighboring wavebands.
- The estimates (Gevorkian et al. 1998) of the X-ray luminosities of AGNs in the framework of a simple physical model are consistent with observational data.

References

Brown, R.L., & Gould,R.J., 1970, Phys.Rev.,D1, 2252

Gevorkian, Zh.S. 1992, Phys.Lett., A162, 187

Gevorkian, Zh.S. 1993, Radiofizika, 36, 36

Gevorkian, Zh.S. & Atayan, S.R. 1990, Phys.Lett., A144, 273

Gevorkian, ZH.S.& Atayan, S.R. 1990, Sov.Phys. JETP 71 (5), 862

Gevorkian, Zh.S., Hambarian,V.V., & Akopian, A.A., 1998, Astrofizika, 41, 443