THE EVOLUTION OF A QUASAR POPULATION BASED ON A
SIMPLE SOURCE MODEL

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Abstract. The cosmological evolution of a population of quasars and AGNs is considered. The applied source model provides that the star collisions in the central stellar system should be the principal mechanism of supply of the gas falling on to the black hole. The continuity equation for the assumed population is solved for the zero birth function as well as for its special type. The solutions obtained depend on the distribution of two parameters characterizing a single source: the radius of stellar core and the number of stars in the system. All these solutions allow to describe practically whole evolutionary track of the considered source population, and to relate the evolution to some features of a single source.

1. Introduction and Summary

The nature of the central part of quasars and AGNs is the main problem arising in constructing a theoretical model of those sources. Many models suggest the gas falling to a massive central black hole as a possible mechanism powering the sources (Begelman et al., 1984; Rees, 1977, 1978). McMillan et al. (1981) gave a short list of possible sources of such a gas. These are:

- stellar collisions in dense stellar systems around the central black hole (Spitzer and Saslaw, 1966; Lightman and Shapiro, 1977, 1978);
- tidal disruption of stars (Hills, 1975; Frank and Rees, 1976);
- normal mass loss by stars;
- neutral hydrogen clouds.

Cavaliere and his collaborators (see Cavaliere et al., 1983, 1985; hereafter referred to as CGMV and CGV, respectively) proposed a general way to construct cosmological evolution of quasars based on their astrophysical properties described by some theoretical models. It has been shown that in the case of simplest quasar models, as simple accretion on to a black hole, spinar as the central part of a source; and a magnetized accretion disk around a black hole, the liberation of gravitational energy can be described in a similar way. This allowed to solve the continuity equation for a quasar population. The problems which should be solved in the next steps are the choice of the birth function of sources and the description of dependence of the functions arising in the continuity equation on the physical features of sources. Next, very difficult, steps are to find general dependences between the gravitational energy liberated in the central source and the luminosity of a quasar in some radiation bands, and to write down the continuity equation for single type of sources separately.

In this work we try to use a simple model of the central region of a quasar to analyze the influence of some physical parameters of sources on the solution of the continuity
equation. The model used is that described by McMillan et al. (1981), which will be presented in short in Section 2. On the basis of this model, the continuity equation for the population of sources was written down and solved for two cases:

1. the total birth function of sources $S = 0$,
2. the non-zero total birth function of a special kind.

The solutions obtained (presented in Section 3) depend on two initial parameters of the central region of a single source, the radius of the stellar core $x_\sigma$ (in the further for simplicity denoted as $x$, and the number of stars in the core, $N_i$ (i stands for 'initial'). Our considerations are restricted to one special model of the central part of a quasar or AGN, contrary to the general solutions given by CGMV. All solutions presented in Section 3 may be treated as a comment on the general solutions obtained by CGMV and CGV, but, different from their results, ours are valid approximately over the entire evolutionary track of a source population and can be applied at earlier times than those of CGMV and CGV, and describing the dependence of the space density and evolution of the considered population on the distribution of two parameters, the number of core stars and the core radius, which characterize a single source at $t = t_0$ ($t_0$ - the initial time). Some conclusions and remarks referring to this matter are presented in Section 4.

Certain problems arising in the use of our solutions and the choice of the parameter distribution will be given in the next paper together with some numerical results.

2. Theoretical Model

McMillan et al. (1981) considered the central part of a quasar or AGN as a system containing a central black hole of mass $M_H$, surrounded by a system of $N$ stars, representing a core of radius $R_c$. It has been assumed that the star collisions and tidal disruptions are the principal gas supply mechanisms.

All the system has been considered as being in a quasi-steady state: so the gas falls onto the central black hole at the same rate as it is liberated, $\dot{M}(t)$. In such a state the total luminosity $L$ as a function of time $t$ satisfies the equation

$$L(t) = k \left( \frac{\varepsilon}{0.1} \right) \left( \frac{\dot{M}(t)}{M_\odot \text{yr}^{-1}} \right),$$

(2.1)

where $k$ is a constant, $k = 7 \times 10^{45}$ erg s$^{-1}$; $\varepsilon$ represents the efficiency of the process of conversion of the gas mass into the energy released in the form of radiation; $\dot{M} = d\dot{M}/dt$ is the rate of the liberation of gas; $M_\odot$ is the solar mass.

In the further considerations we shall use $K = k\varepsilon/0.1$.

McMillan et al. (1981) concluded that both the mechanisms of gas supply lead to a decrease of the function $\dot{M}(t)$; but the condition for $\dot{M}(t)$ to exceed $0.1 M_\odot \text{yr}^{-1}$ for a system with total mass greater than $\sim 10^8 M_\odot$ requires the stellar collisions to be dominant. The theory of stellar collisions (Spitzer and Saslaw, 1966; Colgate, 1967; Lightman and Shapiro, 1978) has been used by McMillan et al. (1981) to describe the liberation of gas in the dense stellar system. Interesting results have been obtained for