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A. Kats, doctor phys-math sci., professor
V. Kontorovich, doctor phys-math sci., professor

Explosive galaxy evolution at high redshifts and hidden mass problem

The "sudden" appearance of massive galaxies at the redshift z=6 discovered in ultradeep Hubble and Subaru fields and observation of the secondary ionization final stage at the same time period can be explained by explosive evolution due to galaxy mergings in the presence of a hidden mass in galaxies.

"Раптове виникнення" масивних галактик на червоному зміщенні z = 6, знайдене в надглибоких полях Хаббла й Субару, та спостереження заключного етапу вторинної іонізації в той же період часу можна пояснити вибуховою еволюцією галактик за рахунок злиттів у присутності схованої маси в галактиках.

Information presented in [1, 6] concerning detection of "sudden" appearance of massive galaxies at the redshift $z=6$ in ultradeep Hubble and Subaru fields (see also [3] and corresponding literature and discussion in review [4]), and observation of the secondary ionization final stage at the same time period [5], as well as the quasars appearance epoch [13], for our opinion can argue for the explosive galaxy evolution while merging, see papers [2, 9] and review [7].

It was long thought that the galaxies tend to evolve in a purely individual fashion after their formation (from protogalaxy clouds) due to development of the gravitational instability The observational data obtained over the past three decades, in particular, the data provided by the space Hubble telescope and the largest ground-based instruments, clearly demonstrate the crucial role of the merging process in the cosmogony of galaxies. A comprehensive overview presented by Kennecutt, Schweizer and Barnes [8], dedicated to the interaction and merging of galaxies as well as to the star formation induced by these phenomena (there are more than 1000 citations and 200 illustrations), allows us to omit a detailed description of the corresponding bibliography and observational arguments.

Such rapid evolution of the massive galaxies number at z=6 redshift discovered in the last years via analysis of the ultradeep Hubble and Subaru field may be explained by the explosive evolution of galaxies merging process in the presence of a hidden mass in galaxies. Reconstructing of the star formation rate gives possibility to discuss the data of the reionization process in this epoch, which confirms the explosive character of the evolution. The merging processes occur in cold dark matter in which the Jeans length is short, although the evolution takes place in the hot Universe.

In the 1990s the Roman and Kharkov (Ukraine) groups [2, 9, 10-12] demonstrated that the kinetic "phase transition" [14,15] may hold in the system of galaxies. This transition shows up as the self-accelerating process of massive galaxy formation through merging of the small mass galaxies: specifically, this is an epoch of galaxy origin. In other words, the process of mergings in the gravitational interaction is of "explosive character". The explosive behavior of coalescences is closely related to the dependence of coalescence probability upon the galaxy masses. To be more exact, the explosive evolution and the corresponding phase transition are attributed to a more rapid increase in probability than the first degree of mass [15, 9]. In modern cosmological theories of hierarchical clustering [16, 17] this situation is either ignored or is not taken into account completely: as result the distributions are self-similar and any redshift is no select.

An attempt can be made to regard the "sudden" occurrence of galaxies at *z*=6 as the observational evidence of "explosive" evolution. This particular phenomenon is precisely what the present paper is devoted to. We restrict here ourselves by a differential version of equations, which describe this process.

Explosive galaxy evolution. Consider solutions of the Smoluchowski kinetic equation (KE) [15]

$$\frac{\partial}{\partial t} f(M,t) = I_{st}, \tag{1}$$

where

$$I_{st} = \iint dM_1 dM_2 \left\{ W_{M|M_1,M_2} f_1 f_2 - W_{M_1|M_2,M} f_2 f - W_{M_2|M,M_1} f f_1 \right\},$$
$$W_{M|M_1,M_2} = U(M_1,M_2)\,\delta(M-M_1-M_2), \quad U(M_2,M_1) = U(M_1,M_2),$$
$$f = f(M,t), \quad etc.$$

In the case when the main contribution to the collision integral follows from small masses of order of M_* we have (cf. [9, 10]):

$$U(M,M_2) = \frac{C}{2} M^u \quad for \quad M_2 \ll M. \tag{2}$$

Expanding the integrand for $M_2 \ll M$ we arrive to KE in the differential form, cf. [9],

$$\frac{\partial}{\partial t} f(M,t) + c\Pi \frac{\partial}{\partial M}\left[M^u f(M,t) \right] = 0, \; \Pi = \int_0 dM_2 M_2 f(M_2,t), \tag{3}$$

where Π is the total mass of interacting galaxies, the number galaxy flux along the mass spectrum is $J(M,t) = C\Pi M^u f(M,t)$. We suppose that the main contribution to the integrals follows from the region $M_2 \ll M$, so the upper limit (M) in the corresponding integrals is omitted.

The solution of Eq. (3) can be received by the method of characteristics and is