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INTERACTION BETWEEN TWO COMPONENT SYSTEMS AND ITS INFLUENCE ON BEHAVIOR OF ADIABATICAL COSMOLOGICAL PERTURBATIONS IN THE EARLY UNIVERSE

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ABSTRACT

We describe the formation of large-scale inhomogeneous structure of expa-nding Universe on the basic of two components system-usual nonrelativistic particles and dark matter,with taking into account their interaction.

Key Words : Subject headings: gravititonal instablity,theory -dark matter,gravitational force of friction

I. INTRODUCTION

The formation of large-scale inhomogeneous structure of the expan-ding Universe is the consequence of gravitational instability of baryons systems in the epoch of period after recombinations, when $Z > 1000$. According to theory the reason of observable in present time inhomogeneities - galaxies and their clusters is gravitational acceleration of primary small perturbations in nonrelativistic substance (NRS) - system of baryons on background dark matter having different equations of state and forms.

Dark matter displays itself only in gravitational interaction and plays a role in formation of a large-scale structure of the Universe.

II. GRAVITATIONAL FORCE OF FRICTION

There are the gravitational force of friction during the interaction of nonrelativistic particles with particles of dark matter. The nature of these forces depends mainly on the temperature of dark matter. If the temperature of dark matter radiation $T_{DM} < 10^7 K$ and speed of particles $v << c$ (c- speed of light), we have classical Thomson process of scattering. In this case the force is acting per unit of volume of substance, consisting of nonrelativistic particles, moving through the dark matter with the speed v, this force is directed towards to this movement and its value is $F_{TP} \sim \frac{v}{c} T_r^4$. At high temperature of dark matter (radiation) $T_r > 10^7 K$ the speed of particles becomes relativistic i.e about the speed of light, then we have quantum processes of scatttering of Klein-Nishina. Forces of friction, connected with these process will be $F_{K-N} \sim \frac{v}{c} T_r^3 Ln(bT_r)$, where $b = Const$ (Reeves and Landsberg 1982).

In the following according to the above-mentioned our main aim is to find out a role of force of gravitational friction, arising during interactions between NRS and components of dark matter with different equations of a state, evolving at various stages of the Universe. In this case the equation with accounting of force of gravitational friction is recorded in a form (Peebls 1975), (Zel'dovich and Novikov 1975), (Kozhanov 1990) :

$$\frac{\partial^2 \delta_i}{\partial t^2} + 2H \frac{\partial \delta_i}{\partial t} + K(R) \frac{\partial \delta_i}{\partial t} = \frac{3 H_0^2 \Omega_i}{2 R^3} \delta_i, \qquad (1)$$

where $K(R)$ - coefficient of force of gravitational friction, which depends on density of dark matter.

For convenience in a equation (1) we shall proceed from independent variable t to the scale factor R using well-known equations of Fridman (Fry 1985,Martel 1995):

$$R^2[\Omega_{NP} + (1 - \Omega_{NP}) R^{3-n}] \cdot \frac{\partial^2 \delta_i}{\partial R^2} + R[\frac{3}{2}\Omega_{NP} + (1 - \Omega_{NP})(3 - \frac{n}{2}) R^{3-n}] \frac{\partial \delta_i}{\partial R} + \frac{K(R)}{H_0} R^{\frac{3}{2}} [\Omega_{NP} + (1 - \Omega_{NP}) R^{3-n}]^{\frac{1}{2}} \frac{\partial \delta_i}{\partial R} = \frac{3}{2} \Omega_{NP} \delta_i. \qquad (2)$$

III. DARK MATTER WITH THE DENSITY R^{-n}, $(n = 3)$

In this case the law of change of density in dependence on R of nonrelativistic substance coincides with the law of density change of dark matter, i.e. the equation (2) is resulted in a form $[K(R) = \frac{\sigma}{R^3}]$:

$$R^2 \frac{\partial^2 \delta}{\partial R^2} + (\frac{3}{2} + \frac{\sigma}{H_0} R^{-\frac{3}{2}}) R \frac{\partial \delta}{\partial R} - \frac{3}{2} \Omega_{NP} \delta = 0, \qquad (3)$$

where $\sigma = const$- characterizes the properties of dark matter. If $\Omega_{NP} = 1$, we have Einstein-de Sitter's model.

The general solution of a equation (3) at any values of Ω_{NP}, has a form:

$$\delta(R) = C_1 R^{-\frac{3}{2}k} \Phi(k, 2k + \frac{2}{3}, \frac{2\sigma}{3H_0} R^{-\frac{3}{2}}) + C_2 R^{-\frac{1}{2} + \frac{3k}{2}} (\frac{2\sigma}{3H_0})^{\frac{1}{3} - 2k} \Phi(\frac{1}{3}, \frac{3}{4} - 2k, \frac{2\sigma}{3H_0} R^{-\frac{3}{2}}), \qquad (4)$$

where the function $\Phi(a, c, x)$ - is the solution of degenerated hypergeometric equation and it is named function of Cummer, C_1, C_2 - constants of integration, k-constant value which is the root of a equation

$$9k^2 - 3k - 6\Omega_{NP} = 0, \qquad k_{1/2} = \frac{1}{6}(1 \pm \sqrt{24\Omega_{NP} + 1}). \tag{4}$$

Thus, root k is sensitive to availability of NRS. The presence of σ means the influence of force of gravitational friction of the part of dark matter on dynamics of perturbations of density NRS. If $\sigma = 0$, forces of gravitational friction are absent.

The main conclusion of the given analysis of solutions (4) is that for large quantitty of dark matter perturbation of density NRS grows very slowly.

Thus, dependences between δ and R are revealed for various Ω_{NP} for cases, when friction is present and without it. It should be note, that when $k = k_2$ and $\frac{3H_0}{2\sigma} \geq 1$ availability of gravitational forces of friction accelerates the growth of perturbations of density of matter, because the growing solution for δ equally depends on the scale factor. If $\frac{3H_0}{2\sigma} \leq 1$, forces of friction slightly decelerate the growth of $\delta(R)$. In general, if the factor of force of gravitational friction, stipulated by properties of dark matter, is small ($\sigma \to 0$), the growth of pertur- bations of density NRS occurs faster, than without force of friction. This phenomenon means, that during formation of inhomogeneity the sticking of particles takes place, and perturbations grow. In the case k_2 - the forces of friction do not influence the growth of perturbations of density of nonrelativistic substance.

Now here we research the perturbation of density of nonrelativistic substance on a backgro-und of matter, under the various stat's equation, i.e., $0 \leq n < 3$. Hence, as it was shown above,$n = 0$ ($P = -\delta c^2 = -\epsilon$) - gravitating vacuum, $n = 1$, ($P = -\frac{2}{3}\delta c^2 = -\frac{2}{3}\epsilon$) - dominated of a walls, $n = 2$, ($P = -\frac{1}{3}\delta c^2 = -\frac{1}{3}\epsilon$) cosmic strings.The consideration of these problems is justified by the fact that last years many researchers frequently assume, that there was a period of dominating of cosmological term ($n = 0$), (Dolgov 1981), (Selvira and Waga 1994). The influence dominated of walls, arising at spontaneous broken discretic symmetry, on the development of the Universe was marked by Zel'dovich and other (1973). It was specified by them that the walls, if they exist, would break observed uniformity of the Universe.

Thus, the evolutionary equation for perturbations of density NRS for various values of free parameter n and in view of gravitational friction has a form (2). With the help of the following substitution of variables $x = \frac{1-\Omega_{NP}}{\Omega_{NP}} R^{3-n}$ equation (2) can be recorded in a form (at $0 \leq n < 3$)

$$(3-n)^2 x^2(1+x)\frac{\partial^2\delta}{\partial x^2} + (3-n)x[(\frac{7}{2}-n)+(5-\frac{3}{2}n)x]\frac{\partial\delta}{\partial x} + \frac{\sigma\Omega_{NP}^{\frac{3(2-n)}{2(3-n)}}}{H_O(1-\Omega_{NP})^{\frac{3-2n}{2(n-3)}}}\sqrt{1+x}(3-n)x^{\frac{9-4n}{2(3-n)}}\frac{\partial\delta}{\partial x} = \frac{3}{2}\delta. \tag{6}$$

When $\sigma = 0$ (the influence of gravitational force of friction is absent), the general solution of a equation (6) is given in the work by Selvira and Waga (1994).

The above-mentioned forms of matter as a whole existed in early epoch of the Universe. Therefore we are interested in the case when the value R is small, i.e., $x \ll 1$. Then (6) has a following form:

$$x^2\frac{\partial^2\delta}{\partial x^2} + [\frac{7-2n}{2(3-n)} + \frac{\beta_n}{3-n}x^{\frac{3-2n}{2(3-n)}}]\frac{\partial\delta}{\partial x} - \frac{3}{2(3-n)^2}\delta = 0, \tag{7}$$

where $\beta_n = \frac{\sigma}{H_0}\Omega_{NP}^{\frac{3(2-n)}{2(3-n)}}(1-\Omega_{NP})^{\frac{2n-3}{2(3-n)}}$. If k- is a root of a equation

$$k^2 + \frac{1}{3-2n}k - \frac{6}{(3-2n)^2} = 0, \qquad k_{1/2} = \frac{-1 \pm 5}{2(3-2n)}. \tag{8}$$

then substitution $\delta(x) = \xi^k u(\xi)$, $\xi = -x^{\frac{3-2n}{2(3-n)}}\frac{2\beta_n}{3-2n}$ leads equation (7) to equation

$$\xi\frac{\partial^2 u}{\partial\xi^2} + (m-\xi)\frac{\partial u}{\partial\xi} - ku = 0. \tag{8}$$

The general solution is Cummer's function with parameters $m = 2k + \frac{2(n-2)}{3-2n}$ and k (7).

$$\delta(x) = C_1(\frac{2\beta_n}{3-2n})^k x^{\frac{3-2n}{2(3-n)}k}\Phi[k, m, -x^{\frac{3-2n}{2(3-n)}}\frac{2\beta_n}{3-2n}] + C_2[\frac{2\beta_n}{3-2n}]^{-\frac{1+(3-2n)k}{3-2n}} x^{-\frac{1+(3-2n)k}{2(3-n)}}\Phi[-\frac{1+k(3-2n)}{3-2n}, -2k + \frac{2(1-n)}{3-2n}, -x^{\frac{3-2n}{2(3-n)}}\frac{2\beta_n}{3-2n}], \tag{10}$$

where C_1 and C_2 - constants of integration.

IV. CONCLUSION

The influence of force of gravitational friction, arising at interaction between these two components of a mix at high temperature on the growth of perturbation of baryons density is investigated. Number of the new solution of equation describing the evolution of linear small-scale perturbation of density of nonrelativistic substances on a above-mentioned background dark matter , the density of which changes with the scale factor of the Universe similarly to R^{-n} ($0 \leq n \leq 4{,}6$) and in view of force of dynamic friction on the part of dark matter is received. It is shown, that the effect of amplification of speed of perturbation growth of density of baryons strongly depends on density of dark substance. The general solution of a equation for cosmological perturbations NRS on a background cosmic matter with negative pressure in case, when $R \ll 1$ ($n < 3$) and in view of force of gravitational friction is found. Effects of this force on speed of growth of perturbations in a early epoch of the universe are revealed.

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