THE COUPLING OF MODES AND THE FORMATION OF POPULATION III OBJECTS

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We consider two density perturbation modes with significantly different length scales λ and L ($\lambda \ll$ L) in a homogeneous Universe within Newtonian approximation. For the two modes the coupling terms in the corresponding Euler-Lagrange and Poisson equations are taken into account within lowest order of approximation. We assume that the λ - mode (high-frequency mode) is superimposed on the large-scale mode in such way that by an appropriate averaging procedure, the global behaviour is determined only by the single L-mode. Locally ($\Delta x \approx \lambda \ll$ L) the space dependence of the L-mode can be neglected in comparison with the λ -mode, but its time evolution remains important for the evolution of the λ -mode perturbation δ . We obtain for δ the equation:

$$\ddot{\delta} + 2\dot{\delta}\left[H - \omega\dot{D}\right] + \delta\left[\omega^2\dot{D}^2 + \omega D k_1^2 \left(A_1 - \omega b^2\right) + k_2^2 A_2\right] = 0, \qquad (1)$$

where $\varrho = \bar{\varrho}(1+D+\delta)$, b is the sound velocity with respect to the undisturbed homogeneous matter distribution, H is the Hubble parameter, $k_1 = 2\pi/L \ll k_2 = 2\pi/\lambda$, $\omega = L/\lambda$
$A = b^2 - 4\pi G\bar{\varrho}/k^2$.
The equ. (1) describes after some time ($\omega\dot{D} > H$) an amplification of δ with respect to the single mode solution, leading to a much shorter evolution time t_1 for δ . t_1 decreases with growing ratio L/λ . δ will be amplified only in the region of positive density contrast D. It is reasonable to consider for the characteristic mass of the large-scale perturbation the maximum of the Jeans mass $\approx 10^{16}$ $M_\odot$. Taking into account the observed limits on the background radiation fluctuations at the recombination epoch, we obtain, in dependence of the special choice of the parameters H, D_0, δ_0 , for the objects which condensed firstly the mass range $M/M_\odot$ = 30 to 300 (within the redshift range z=100 to 10), typical for the considered population III objects.

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J. Audouze et al. (eds.), Large Scale Structures of the Universe, 591.
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https://doi.org/10.1017/S0074180900137179 Published online by Cambridge University Press