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One-dimensional models of cosmological perturbations: direct integration in the Fourier space

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We propose a numerical approach to study the inhomogeneity growth in the Universe filled with a pressureless matter. The hydrodynamical equations for perturbations of the isotropic uniform cosmological background (non-relativistic stage) in the comoving frame are treated taking into account all nonlinear terms. The periodic boundary conditions are imposed. The problem is reduced to ordinary differential equations for an infinite chain of Fourier coefficients for hydrodynamical variables. We perform a numerical integration of these equations for randomly generated initial conditions (with proper truncation of the coefficients). This procedure is repeated for a number of representations of the ensemble of initial conditions to obtain a power spectrum of the density contrast. We test the method in two problems. (i) We derived an exact implicit solution which describes a one-dimensional collapse of plane gravitating shells. This is used to check the numerical solution for the Fourier coefficients and for the power spectrum. (ii) In case of the standard three-dimensional hydrodynamical equations but with one-dimensional (plane) initial conditions we proceed only numerically to derive first coefficients of the power spectrum. The results are used to study a nonlinear interaction of different Fourier modes. We estimate a realizability of this method as an alternative to the cosmological N-body simulations in case of a mildly non-linear situation.

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