Prepared for submission to JCAP

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Abstract.

Contents

1 Relativistic Poisson equation

The conformal Newtonian gauge (also known as the longitudinal gauge) reads https://arxiv.org/abs/astro-ph/9506072-

$$ds^2 = a^2(\tau)\Big[-(1+2\Psi)d\tau^2 + (1-2\Phi)dx_i dx^i\Big] \tag{1.1}$$

The (0,0) component of first order perturbed Einstein equation gives,

$$k^2\Phi + 3\mathcal{H}\Big(\Phi' + \mathcal{H}\Psi\Big) = -4\pi G a^2 \bar{\rho}\,\delta \tag{1.2}$$

The last equation is called relativistic Poisson equation which for small scales ($k \gg \mathcal{H}$) and using the fact that Φ' is very suppressed in general we can retrieve the Newtonian Poisson equation, which reads as,

$$k^2\Phi = -4\pi G a^2 \bar{\rho}\,\delta \tag{1.3}$$

1.1 Newtonian Poisson equation in the k-evolution

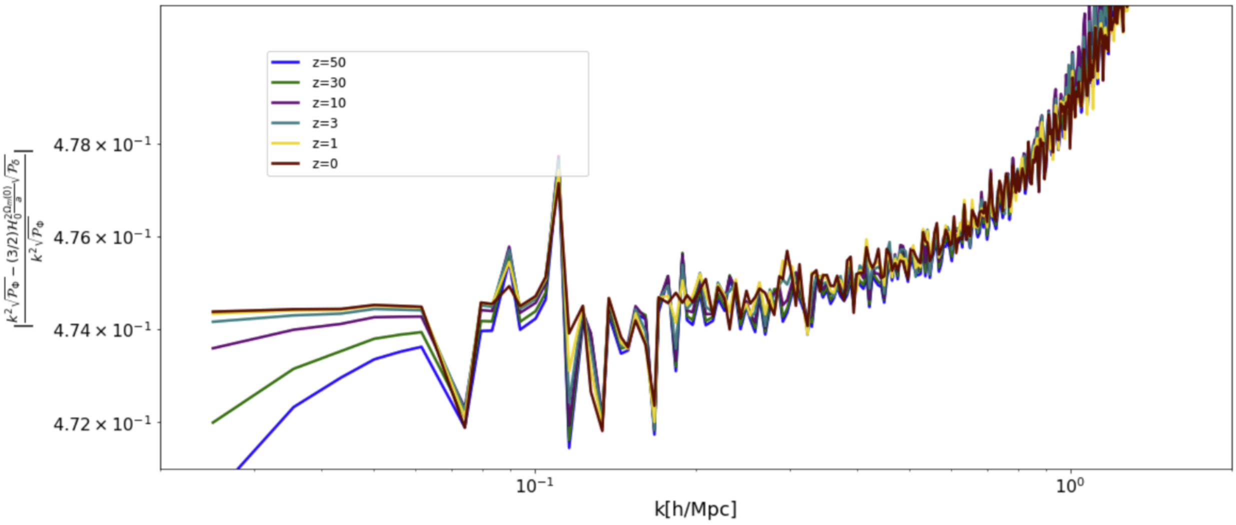
Here we are going to compare $\mathcal{P}_\delta$ from Poisson equation to the output one to see how much Newtonian Poisson equation is valid. We also can compute $k^2\Phi + 4\pi G a^2\bar{\rho}\delta$ but we need to take care of the signs. To obtain Φ, δ and etc. we use the following relations

$$\mathcal{P}_\Psi = \Psi_k^2\,,\ \mathcal{P}_\delta = \delta_k^2 \tag{1.4}$$

and also $\rho_m = \rho_m(0)/a^3$ and $4\pi G\rho_{cr} = (3/2){H_0}^2$, so we have $4\pi G\rho_m a^2 = 4\pi G\frac{\rho_m(a)}{\rho_{cr}(0)}\rho_{cr}(0)a^2 = 4\pi G\frac{\Omega_m(0)a^{-3}\rho_{cr}}{\rho_{cr}(0)}\rho_{cr}(0)a^2 = (3/2){H_0}^2\Omega_m(0)a^{-3}a^2 = (3/2)\mathcal{H}_0^2\Omega_m(0)/a$
Assuming that only matter clusters, which is not completely true in the case of k-essence we have,

$$4\pi G a^2\bar{\rho}\delta = (3/2)\mathcal{H}_0^2\frac{\Omega_m(0)}{a}\sqrt{\mathcal{P}_\delta} \tag{1.5}$$

We are going to compute $|\frac{k^2\sqrt{\mathcal{P}_\Phi} - (3/2)\mathcal{H}_0^2\frac{\Omega_m(0)}{a}\sqrt{\mathcal{P}_\delta}}{k^2\sqrt{\mathcal{P}_\Phi}}|$ to test the Newtonian Poisson equation,

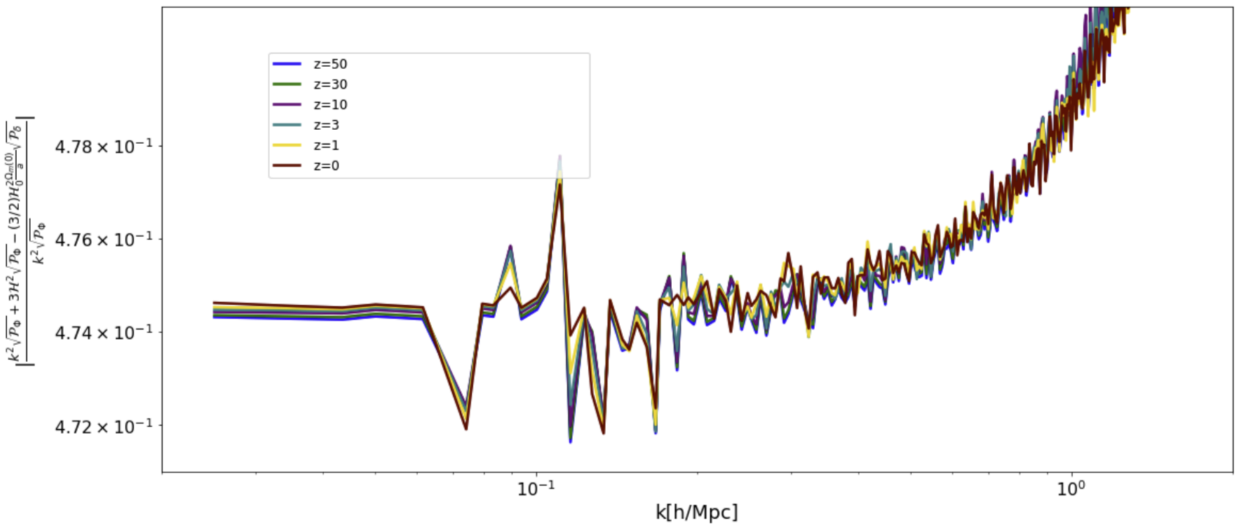


1.2 Relativistic Poisson equation

Now we want to check if we can reduce the error of Newtonian Poisson equation by considering relativistic terms as following.

$$\left| \frac{k^2\Phi + 3\mathcal{H}\left(\cancelto{0}{\Phi'} + \mathcal{H}\Psi\right) - (3/2)\mathcal{H}_0^2\Omega_m(0)\sqrt{\mathcal{P}_\delta}(1+z)}{k^2\Phi} \right| \approx 0 \tag{1.6}$$

We neglect Φ' because it is almost suppressed. We get the following plot, We expect to get "0" in the Gevolution by computing the last expression.



2 Conclusions

Acknowledgements

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