# Readme: dn-N-GenIC

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This is an explainer file for dn-N-GenIC, a modification of the initial conditions generation code for the N-body simulation code GADGET-2, that includes parameterizations for a varying equation of state of dark energy, and modifications for small-scale suppression due to massive neutrinos in the power spectrum used to generate ICs.

The code can be used to generate ICs for DGADGET-2, to incorporate time variation for the dark energy parameter of state in both the input file and the simulations.

**Dark Energy Models** dn-N-GenIC gives the option of using one of four models of a time-varying equation of state for dark energy while generating initial conditions. All four of these use two free parameters:

1. $w_0$: the current equation of state of dark energy.
2. $w_1$: the effective $dw/dz$ in linear models of the equation of state, that models the deviation from a constant $w_0$.

**[1] Linder (2003) :** Linear in $a(t)$.

$$w(a) = w_0 + w_1(1-a)$$

**[2] Jassal et. al. (2005):** Quadratic in $a(t)$, accounts for rapid variation at late times.

$$w(a) = w_0 + w_1 a(1-a)$$

**[3] Barboza and Alcaniz (2008):** Bounded for all $z$.

$$w(a) = w_0 + \frac{w_1(1-a)}{a^2 + (1-a)^2}$$

**[4] Wetterich (2004):** Zero equation of state at high $z$.

$$w(a) = \frac{w_0}{[1 - w_1 \log a]^2}$$

**Massive Neutrinos** The program also modifies the Hu-Eisenstein transfer function to include time-dependent growth due to massive neutrinos, with fit formulae taken from [5].

The modified transfer function, which encodes perturbations for the combination of cold dark matter, baryons and neutrinos, is given by the time and scale dependent form:

$$T_{cb\nu}(k, z) = T(k)\frac{D_{cb\nu}(k, z)}{D(z)}$$

**Parameter File Options** The parameter file uses three extra parameters (besides a normal GADGET-2 parameter file) to quantify the dark energy models:

1. `CurDEParam`: Current equation of state $w_0$.
2. `DEParamCoeff`: Parameter $w_1$.
3. `DEParamChoice`: Choice of parameterization. Setting to `0` corresponds to standard LCDM cosmology with $w = -1$. The choices `1` through `4` correspond to models **[1]** through **[4]** in order from above.

It also provides two parameters for setting massive neutrinos up:

1. `OmegaNu`: Density parameter of neutrinos $\Omega_\nu$.
2. `NoOfDegenNu`: No. of degenerate massive neutrino species (Must be set to a non-zero integer).

A sample parameter file is provided in the source folder, by the name of `ics.param`.

# References


[1] Linder, E. V. 2003, Phys. Rev. Lett., 90, 091301

[2] Jassal, H. K. Bagla, J. S., & Padmanabhan, T. 2005, MNRAS, 356, L11

[3] Barboza, E. M., & Alcaniz, J. S. 2008, Phys. Lett. B, 666, 415

[4] Wetterich, C. 2004, Phys. Lett. B, 594, 17

[5] Eisenstein, D. J., & Hu, W. 1999, ApJ, 511, 5