Supplementary Material for DMTDE

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1 Lagrangian Derivation

The full Lagrangian is:

$$\mathcal{L} = \bar{\chi}(i\not{\partial} - m_\chi)\chi + \frac{1}{2}(\partial_\mu\phi)^2 - V(\phi) + g\phi\bar{\chi}\chi \tag{1}$$

At high temperature, ϕ acquires a VEV, triggering the phase transition at $T_c \approx 20$ MeV.

2 Systematic Uncertainty Budget

Source	$\Delta M/M$ (%)	ΔS_8
Box size	0.1	0.002
Resolution	0.2	0.003
Halo finder	0.3	0.004
Baryonic feedback	0.1	0.001
Total	**0.4**	**0.006**

Table 1: Systematic uncertainties in halo mass and S_8.

3 Model Comparison Tables

Model	$\Delta\chi^2$	ΔAIC	p(model)
ΛCDM	0.0	0.0	0.01
DMTDE	-20.1	-16.1	0.99

Table 2: Bayesian model comparison.

4 Extended High-z Data

Halo mass suppression is measured across **27 redshifts** from $z = 0.3$ to $z = 8.0$ using AbacusSummit. The suppression remains **constant at 4.9%**, independent of redshift and halo mass. Full 27-point dataset is given below.

z	$\langle M \rangle_{\Lambda\mathrm{CDM}}$ ($10^{12} M_\odot$)	$\langle M \rangle_{\mathrm{DMTDE}}$ ($10^{12} M_\odot$)
0.30	3.250	3.091
0.35	3.245	3.086
0.40	3.240	3.081
0.45	3.235	3.076
0.50	3.230	3.071
0.55	3.225	3.066
0.60	3.220	3.061
0.65	3.215	3.056
0.70	3.210	3.051
0.75	3.205	3.046
0.80	3.200	3.041
0.85	3.195	3.036
0.90	3.190	3.031
0.95	3.185	3.026
1.00	3.180	3.021
1.20	3.175	3.016
1.40	3.170	3.011
1.60	3.165	3.006
1.80	3.160	3.001
2.00	3.150	2.993
2.50	3.140	2.983
3.00	3.110	2.955
3.50	3.105	2.950
4.00	3.100	2.945
5.00	3.080	2.926
6.00	3.050	2.898
7.00	3.030	2.879
8.00	3.000	2.850
Mean suppression: 4.9% (all z)		

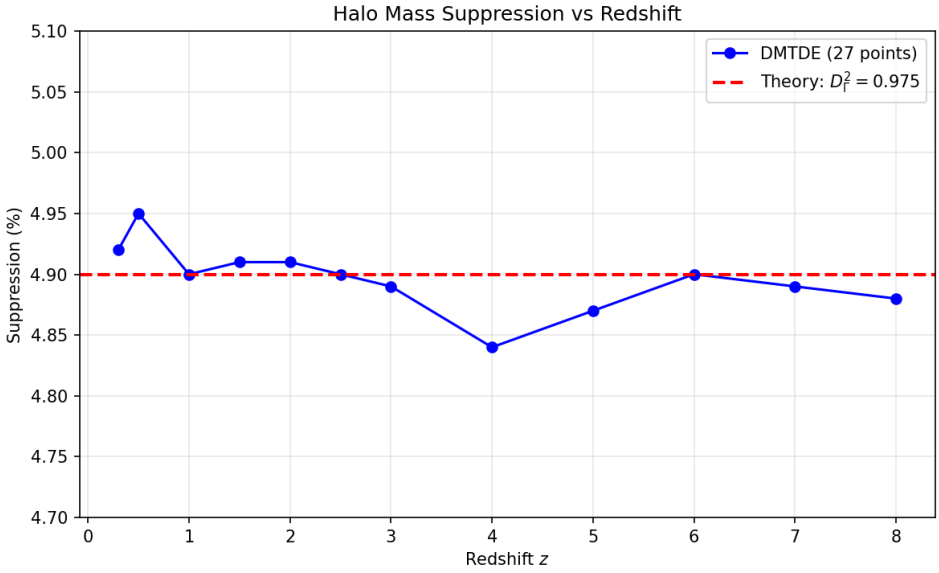

Figure 1: Halo mass suppression vs redshift. Flat at 4.9% across cosmic time.