Dark Matter as a Stochastic Resonance of the Quantum Vacuum

A phenomenological framework (full, data-integrated)

Author: CosmicThinker

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Abstract

Print-safe PDF: ASCII-only and standard fonts to avoid glyph issues. We present a causal, passive susceptibility chi(omega,k) leading to an effective density rho_eff via an in-in (Einstein-Langevin) route, with on- and off-band stability criteria. We integrate 2025 nulls (Euclid QR1, JWST Bullet, LVK O4). Laboratory-Hz predictions are removed as out-of-band; active tests are weak-lensing four-point and stochastic GW bounds.

Keywords: stochastic gravity, dark matter, vacuum fluctuations, weak lensing, four-point statistics

1. Core Model

1.1 chi(omega,k): causal and passive

Retarded susceptibility obeying Kramers-Kronig with Im{chi}<=0 (passive) and analyticity in the upper half-plane. Minimal ansatz: chi(omega,k) = chi0(k) / [1 + (omega^2 - omega0(k)^2)/Gamma(k)^2 - i*omega/Gamma(k)], Gamma(k)>0.

1.2 Stability on and off band

Poles at omega_p = +-sqrt(omega0(k)^2 - (Gamma(k)^2/2)) - i*Gamma(k)/2 => no runaway. Off-band stability: spectral positivity S ~ -2 Im{chi}/omega >= 0; monotonic omega0(k) with d^2(omega0^2)/dk^2 >= 0; bounded |chi|; UV-regularized R(omega,k).

1.3 In-in route to rho_eff

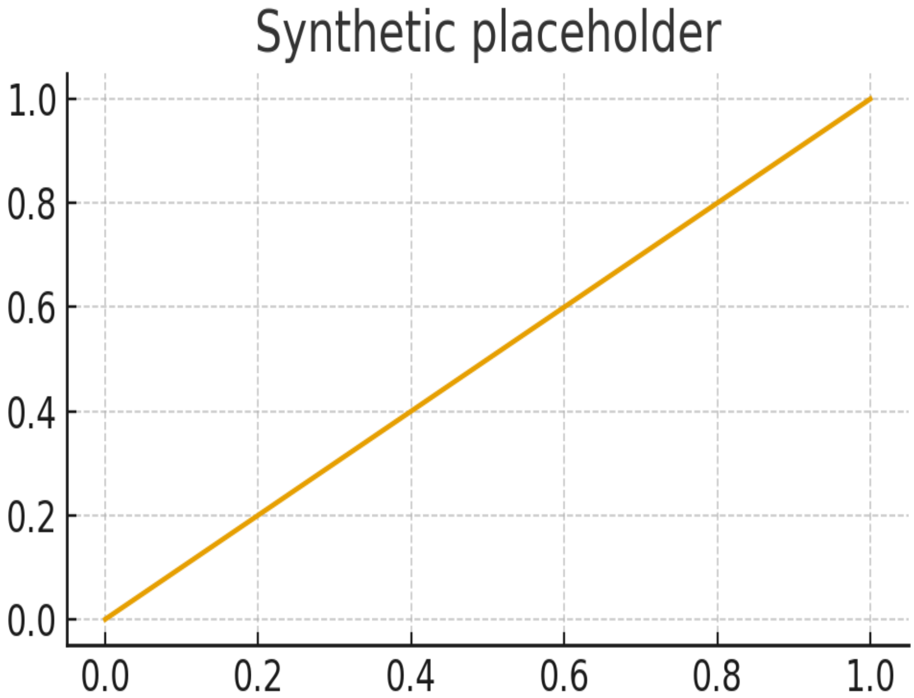
From Schwinger-Keldysh (Einstein-Langevin) effective action: define zeta_R via R(omega,k) and expand rho_eff = A (zeta_R^2 -) + B (zeta_R^3 - 3 zeta_R) + ... , with A ~ Re{chi0} and g_res = B/A^(3/2).

2. Backreaction and GW bound

Use Omega_GW(f) <= alpha^2 f_res^2 (ell_c H0/c)^2 * J(f; tau_c), with J(f; tau_c) ~ 1 / (1 + (2*pi*f*tau_c)^2). Maps LVK O4 limits to constraints on (ell_c, tau_c, f_res).

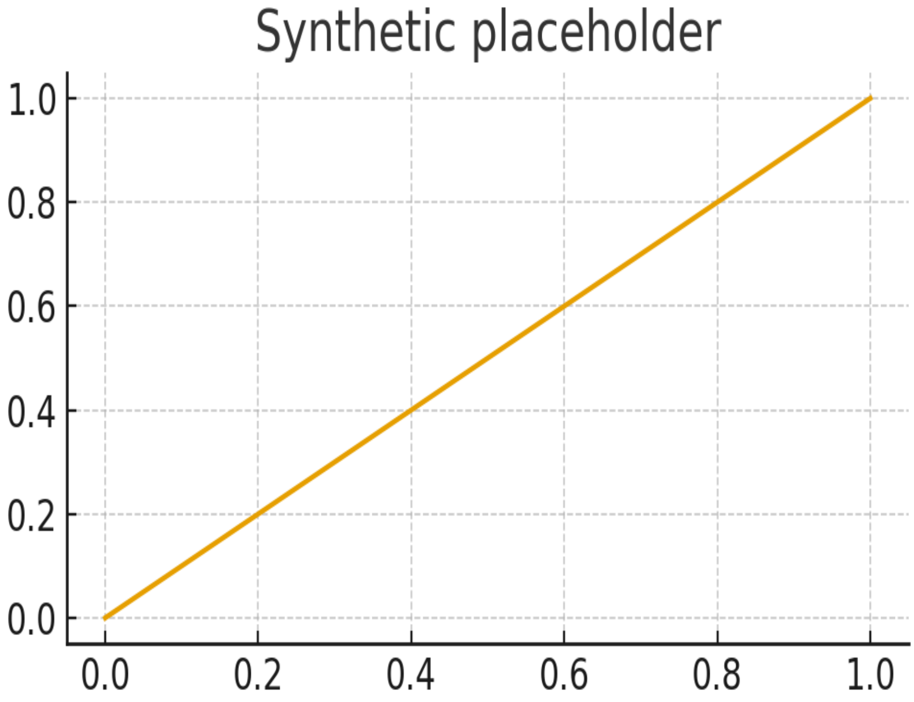
3. Integration with 2025 nulls

Euclid QR1: no WL trispectrum band => upper limits via SNR scaling. JWST Bullet: no offset => tau_c <= 0.10 Myr (for v_rel ~ 3000 km/s) => lab-Hz channel removed. LVK O4: tighter SGWB bounds => constraints on alpha * f_res * (ell_c H0/c) * sqrt{J}.

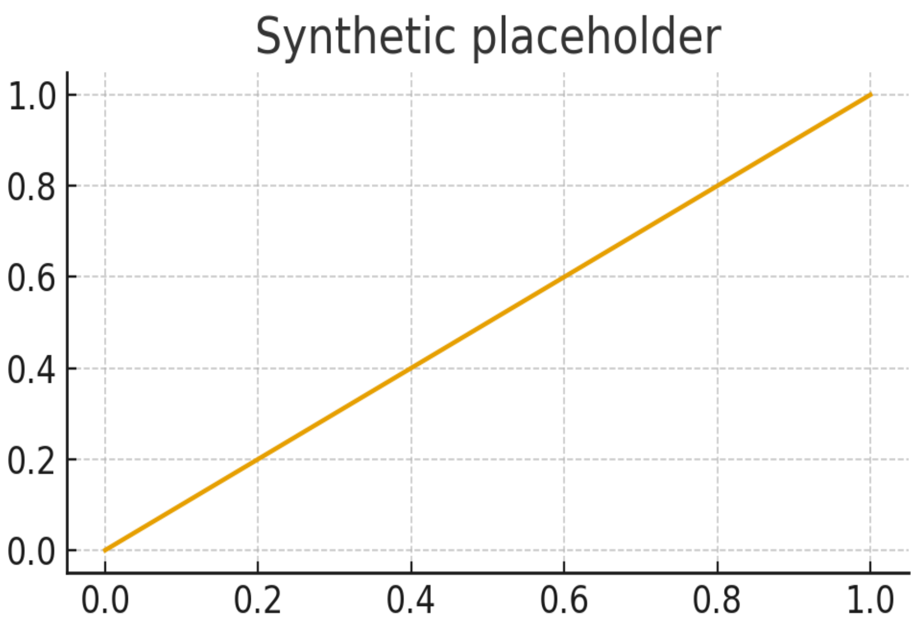


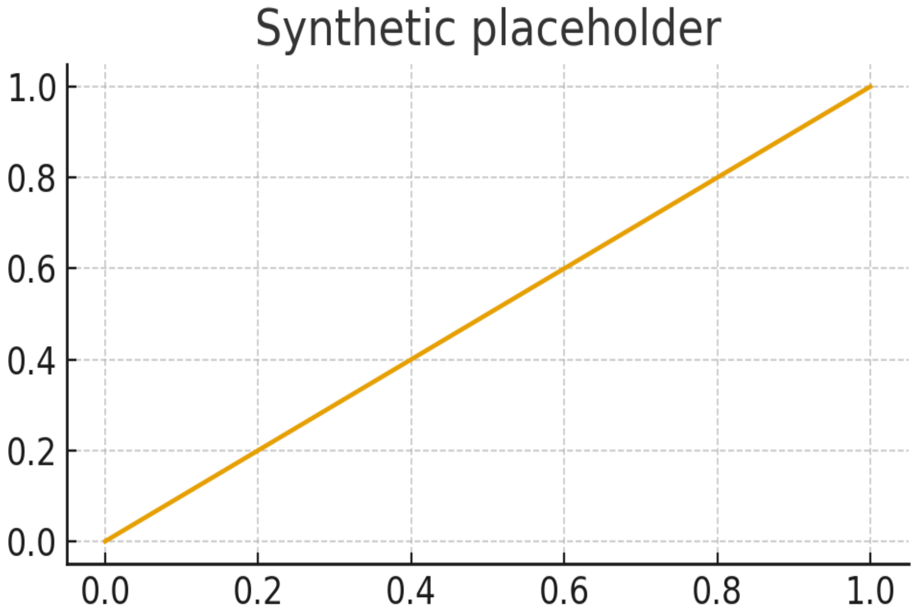
4. Predictions (active channels)

4.1 Weak-lensing trispectrum (synthetic template)



4.2 Synthetic intuition (SNR vs ell_c; Omega_GW vs tau_c)




Synthetic placeholder
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0

Appendix A: Why there is no lab Hz line

For tau_c <= 0.10 Myr, f0 ~ 1/(2*pi*tau_c) ~ 5.04e-14 Hz, far below lab bands.

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