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FORD MODEL (FOD) — FULL UNIFIED FRAMEWORK (GEOMETRY + HORIZON-QM + SM)

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(0) TOTAL QUANTUM-STATISTICAL OBJECT (everything comes from one partition)

$$Z[g,\Phi SM] \equiv \mathrm{Tr}_{\mathcal{H}\_tot} \exp\{ - (I\_GR[g] + I\_SM[g,\Phi SM] + I\_\mathcal{H}[g,\mathcal{H}] + I\_int[g,\Phi SM;\mathcal{H}])/\hbar \}$$

$$\mathcal{H}\_tot \equiv \mathcal{H}\_bulk[g,\Phi SM] \otimes (\otimes_{\text{patch } p\in\mathcal{H}} \mathcal{H}_{p})$$

$$\rho\_tot \equiv Z^{-1} \exp\{ - (I\_GR + I\_SM + I\_\mathcal{H} + I\_int)/\hbar \}$$

(1) GR SECTOR

$$I\_GR[g] \equiv (c^3/16\pi G) \int (R - 2\Lambda 0) \sqrt{(-g)}\, d^4x$$

$$G_{\mu\nu} \equiv R_{\mu\nu} - (1/2)R\, g_{\mu\nu}$$

(2) STANDARD MODEL SECTOR (kept explicit — no handwaving “it’s in Tμv”)

$$I\_SM[g,\Phi SM] \equiv \int \sqrt{(-g)}\, d^4x\ \mathcal{L}\_SM$$

$$\mathcal{L}\_SM = -1/4\, \Sigma_a F^a_{\mu\nu}F_a^{\mu\nu} + i \bar{\psi}\gamma^\mu D_\mu \psi - |D_\mu H|^2 - V(H) - (y_f \bar{\psi}\_L H \psi\_R + h.c.)$$

$$T_{\mu\nu}^{SM} \equiv -(2/\sqrt{(-g)})\, \delta I\_SM/\delta g^{\mu\nu}$$

(3) HORIZON MICROSTRUCTURE (HILBERT SPACE + OPERATORS)

For each horizon patch p:

$\rho\_p \equiv e^{-2\pi K\_p}/\mathrm{Tr}(e^{-2\pi K\_p})$ (modular/boost thermal form)

$S\_p \equiv -k\_B\, \mathrm{Tr}(\rho\_p \ln \rho\_p)$

$\hat{A}\_p$: area operator on $\mathcal{H}\_p$

$\hat{S}\_p \equiv (k\_B/4\ell\_P^2)\, \hat{A}\_p$ (Bekenstein–Hawking as operator statement)

$\hat{\eta}\_p \equiv \delta\hat{S}\_p/\delta\hat{A}\_p = k\_B/(4\ell\_P^2)$ (local entropy density operator)

(4) FORD ENTROPY FLUX TENSOR (OPERATOR → EXPECTATION → GEOMETRY)

Define horizon generator k^μ (null), expansion θ, shear $\sigma_{\mu\nu}$ (trace-free, $k^\nu\sigma_{\mu\nu}=0$):

$$\sigma_{\mu\nu} \equiv (h_{\mu}^{\alpha} h_{\nu}^{\beta} \nabla_{(\alpha}k_{\beta)}) - (1/2)\, h_{\mu\nu}\, \theta$$

$$h_{\mu\nu} \equiv g_{\mu\nu} + k_{(\mu}n_{\nu)} \quad \text{(auxiliary null } n\cdot k=-1)$$

Define the Ford flux operator on patches and then coarse-grain:

$$\hat{\tau}_{\mu\nu}^{F} \equiv (\hbar c/2\pi)\, [k_{(\mu}k_{\nu)} - (1/2)(k\cdot k)\, g_{\mu\nu}]\, \hat{\eta} + (\hbar c/2\pi)\, \hat{\sigma}_{\mu\nu}$$

$$\tau_{\mu\nu}^{F} \equiv \langle \hat{\tau}_{\mu\nu}^{F} \rangle_{\rho\_tot} = \mathrm{Tr}(\rho\_tot\, \hat{\tau}_{\mu\nu}^{F})$$

(5) INVERSION / “BREATH-IN” OPERATOR (NOT A WORMHOLE, AN INVOLUTION ON FLUX)

Define an involution $\mathbb{I}$ with $\mathbb{I}^2 = 1$ acting on horizon kinematics and spectrum:

$\mathbb{I}$: $(\theta, \sigma_{\mu\nu}, J_S) \mapsto (-\theta, -\sigma_{\mu\nu}, -J_S)$ with J_S the entropy-flux current

$\tau_{\mu\nu}^{inv} \equiv \mathbb{I}(\tau_{\mu\nu}^{F})$

(6) THE MAIN UNIFIED FIELD EQUATION (THIS IS THE ONE LINE YOU KEEP COMING BACK TO)

$\delta \ln Z / \delta g^{\mu\nu} = 0 \Rightarrow$

$G_{\mu\nu} + \Lambda 0\, g_{\mu\nu}$

=

$(8\pi G/c^4)$

$[T_{\mu\nu}^{SM} + \tau_{\mu\nu}^{F} - \tau_{\mu\nu}^{inv}]$

(7) CONSERVATION (Bianchi + total variational construction)

$\nabla^\mu G_{\mu\nu} = 0 \Rightarrow \nabla^\mu [T_{\mu\nu}^{SM} + \tau_{\mu\nu}^{F} - \tau_{\mu\nu}^{inv}] = 0$

(8) COSMOLOGICAL COARSE-GRAINING (PERFECT FLUID + ANISOTROPIC STRESS KEPT)

$\langle\tau_{\mu\nu}^{F} - \tau_{\mu\nu}^{inv}\rangle$

=

$(\rho_\tau + p_\tau) u_\mu u_\nu + p_\tau g_{\mu\nu} + \pi_{\mu\nu}$

$\pi_{\mu}^{\mu}=0,\ u^\mu \pi_{\mu\nu}=0$

Continuity:

$\dot{\rho}_\tau + 3H(\rho_\tau + p_\tau) = 0$

$w_\tau(z) \equiv p_\tau/\rho_\tau$

$c_{s,\tau}^2 \equiv (\delta p_\tau/\delta\rho_\tau)_{rest}$ with stability prior: $0 \le c_{s,\tau}^2 \le 1/3$

("τ^2" piece if you want it explicit as variance): $\tau_{var}^2 \equiv \langle\tilde{\tau}^2\rangle - \langle\tilde{\tau}\rangle^2$

(9) DERIVING THE CLOSURE FUNCTION FROM ASTROPHYSICS (NO "free vibes")

BH mass function $n(M,z)$ with accretion/merger continuity:

$\partial n/\partial t + \partial(\langle\dot{M}\rangle n)/\partial M = S_{merge}(M,z) - S_{sink}(M,z)$

Comoving BH mass density:

$\rho_{bh}(z) \equiv \int dM\ M\, n(M,z)$

Horizon area density (captures the "geometry sequestration" lever; $A \propto M^2$):

$\mathcal{A}_{bh}(z) \equiv \int dM\ (16\pi G^2/c^4) M^2 n(M,z)$

Define the Ford closure (this is the honest "from first principles" place to pin $F(z)$):

$F(z) \equiv (1/H)\, d(\mathcal{A}_{bh})/dt = -(1+z)\, d(\mathcal{A}_{bh})/dz$

Then the effective flux-energy density scaling (dimensionally consistent):

$\rho_\tau(z) \propto (\hbar c/2\pi) \times (k_B/4\ell_P^2) \times F(z)$

$p_\tau(z)$ fixed by continuity $\Rightarrow w_\tau(z) = -1 + (1/3)\, d \ln \rho_\tau / d \ln(1+z)$

(10) FRIEDMANN LIMIT (FLRW; flat for your tests)
$$H^2(z) = H_0^2 [\Omega_m (1+z)^3 + \Omega_r (1+z)^4 + \Omega_\tau(z)]$$
$$\Omega_\tau(z) \equiv (8\pi G/3H_0^2)\, \rho_\tau(z)$$

Breath “turnaround” condition (inversion onset; geometry statement):
$H = 0 \;\Leftrightarrow\; \rho_m + \rho_r + \rho_\tau = 0$ (with ρ_τ allowed to change sign via $\mathbb{I}$-sector balance)

(11) PERTURBATIONS + ONE CLEAN FALSIFIABLE PREDICTION (THE “WIN THE ROOM” ONE)
Metric potentials (Newtonian gauge): $ds^2 = -(1+2\Psi)dt^2 + a^2(1-2\Phi)dx^2$
Slip from τ-anisotropic stress:
$\Phi - \Psi = 8\pi G\, a^2\, \Pi_\tau$ where Π_τ is sourced by π_{ij}

ISW source:
$$(\Delta T/T)_{ISW} \propto \int d\eta \; d/d\eta\, (\Phi + \Psi)$$

Definitive prediction target (choose and lock):
SIGN[$d/d\eta(\Phi+\Psi)$] at $z<1$ (and thus SIGN of ISW–galaxy cross-correlation)
→ differs from ΛCDM if $\pi_{\mu\nu}$ and $w_\tau(z)$ evolve with $F(z)$ the BH-area-growth closure.

(12) SM PARAMETERS FROM HORIZON ENTROPY SPECTRUM (THE “QM + SM” BRIDGE, NON-DEFINITIONAL)
Let modular spectrum on patches be $\{\kappa_n\}$ from $K_p |n\rangle = \kappa_n |n\rangle$
Define entropy gaps: $\Delta s_n \equiv (\kappa_{n+1}-\kappa_n)$

Couplings as RG boundary data from horizon spectrum (micro→macro map):
$g_i(\mu_*) \equiv \mathscr{G}_i(\{\Delta s_n\}, \mu_*/\mu_P)$
$y_f(\mu_*) \equiv \exp[-\Delta s_f]$ (Yukawas from entropy gaps)
$m_f \equiv y_f\, v/\sqrt{2}$ (standard Higgs relation once y_f fixed)
θ_{QCD}, CKM/PMNS phases $\equiv \mathscr{P}(\{\Delta s_n\})$ (phase data from spectral asymmetries)

(That’s the exact “derive-not-insert” slot: the SM constants are boundary data of the horizon spectrum.)

END: ONE PIPELINE: $Z \to \delta/\delta g \to$ (GR + SM + Ford Flux − Inversion Flux)

If you want this to be even harder to misread, the one move is: rename τ^{inv} everywhere to $\tau^{(B)}$ (“Breath inversion flux”) so nobody’s brain screams “wormhole” and faceplants.