The Triadic Asymmetry Principle (TAP): Foundations, Dynamics, and Cosmological Predictions

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Abstract

We formulate the Triadic Asymmetry Principle (TAP) as a dual-sector cosmology in which the Universe and Anti-Verse are linked across a non-singular symmetry surface by a Motion–Time exchange ($M \leftrightarrow T$). A symmetry-consistent, expansion-coupled portal $Q = \xi H \rho_\phi$ modifies the continuity equations while preserving diffeomorphism invariance, yielding an effective equation of state $w_{\rm eff}(z)$ and a distinctive growth friction. The framework alleviates the H_0 tension, predicts a mild evolution of $w(z)$ at $1 \lesssim z \lesssim 2$, and implies a natural $(\Omega_Q, \Omega_m, \Omega_\phi) \simeq (0.05, 0.27, 0.68)$ partition for $\xi \sim 0.2$, with $G_{\rm eff} \simeq G$ and UV stability ($c^2_{s,\phi} \to 1$).

0. Foundational Context and Motivation

Triadic Resonance in the Universe. TAP posits that physical reality emerges through a cyclic, triadic interplay among *Motion* (M), *Time* (T), and *Space* (S). In our Universe the causal alteration follows

$$M \ \rightarrow \ T \ \rightarrow \ S \ \rightarrow \ M,$$

with each arrow read as "alters *within*" the remaining channel:

- **Motion alters Time within Space** — manifested as time dilation in SR/GR: relative motion (and gravitational potential) reshapes proper time along worldlines embedded in spatial geometry.
- **Time alters Space within Motion** — realized as cosmic expansion: the forward flow of time stretches spatial hypersurfaces within a dynamical background carrying matter/motion content, giving rise to a late-time acceleration channel.
- **Space alters Motion within Time** — encoded by gravitational curvature: spatial geometry redirects geodesics (motion) within the ambient time flow, i.e. Newtonian gravity/GR as curvature-driven deflection of trajectories.

Together these close a causal loop (*Triadic Resonance*) that is globally consistent and locally testable.

Antiverse Mirror. TAP further proposes an Anti-Verse related by reversed time orientation and a mirror triadic sequence,

$$S \;\to\; T \;\to\; M,$$

which induces a natural parity asymmetry: our Universe trends matter-dominant while the Anti-Verse trends antimatter-dominant. The Universe/Anti-Verse pair meet across a non-singular hypersurface Σ where a Motion–Time ($M \leftrightarrow T$) exchange acts while preserving spatial continuity. The phenomenological imprint at late times is a small, symmetry-constrained exchange portal $Q = \xi H \rho_\phi$ linking dark-energy and matter sectors.

From Philosophy to Dynamics. In TAP, the Motion–Time exchange is realized at the level of the expansion scalar: $Q = \xi H \rho_\phi$, with $H \equiv \dot{a}/a$. This yields controlled deviations from ΛCDM that are continuous in $\xi \to 0$ yet predictive at $\mathcal{O}(\xi)$ for background and growth observables. In this view, late-time acceleration and mild growth suppression are not *ad hoc*, but the dynamical footprint of deeper triadic reciprocity.

1 Introduction

Observational tensions between early- and late-universe determinations of the Hubble parameter, alongside weak-lensing inferences of a lower S_8, motivate symmetry-based extensions of ΛCDM. TAP restores causal parity between Motion and Time via a dual-sector construction with a small, symmetry-constrained exchange portal. In its minimal realization,

$$\nabla_\mu T^\mu{}_\nu = Q_\nu, \qquad Q_\nu = \xi H \rho_\phi u_\nu \;\Rightarrow\; w_{\rm eff} = w_\phi - \frac{\xi}{3}\frac{\rho_\phi}{\rho_m + \rho_\phi}, \qquad \frac{\Gamma}{H} = -\xi \frac{\rho_\phi}{\rho_m}, \tag{1}$$

where $H \equiv \dot{a}/a$, u^μ is the comoving four-velocity, and Γ is the TAP growth-friction term. The $\xi \to 0$ limit continuously recovers ΛCDM. We later show in §4 how the same symmetry suggests a particle-level realization via an ultra-heavy gravitino.

2 Mathematical Framework of TAP

2.1 Kinematics: dual spacetimes, fields, and the triadic algebra

Let $(\mathcal{M}, g)$ denote the (forward-time) Universe and $(\widetilde{\mathcal{M}}, \tilde{g})$ the Anti-Verse with reversed time orientation. TAP introduces three primitive channels $X = \{M, T, S\}$ encoded by a cyclic algebra

$$\mathcal{A} = \mathrm{span}\{e_M, e_T, e_S\}, \qquad e_M e_T = e_S, \quad e_T e_S = e_M, \quad e_S e_M = e_T, \tag{2}$$

with Z_3 cyclic operator $C : e_M \mapsto e_T \mapsto e_S \mapsto e_M$ and a Z_2 automorphism implementing the Motion–Time swap,

$$P_{MT} : e_M \leftrightarrow e_T, \qquad e_S \mapsto e_S. \tag{3}$$

Channel-labeled derivations acting on fields ϕ realize the "alteration" semantics,

$$D_M[\phi] = u^\mu \nabla_\mu \phi, \qquad D_T[\phi] = n^\mu \nabla_\mu \phi, \qquad D_S[\phi] = h^{\mu\nu} \nabla_\mu \nabla_\nu \phi, \qquad h^{\mu\nu} = g^{\mu\nu} + n^\mu n^\nu, \tag{4}$$

and the commutators close as $[D_M, D_T] \sim D_S$, $[D_T, D_S] \sim D_M$, $[D_S, D_M] \sim D_T$.

2.2 Dynamics: dual-sector action and exchange symmetry

We posit an action with two metric sectors and a weak, symmetry-constrained link

$$S = S_{\rm grav}[g] + S_{\rm grav}[\tilde{g}] + S_{\rm matt}[g,\Phi] + S_{\rm anti}[\tilde{g},\tilde{\Phi}] + S_{\rm link}[g,\tilde{g};\Phi,\tilde{\Phi}], \tag{5}$$

$$S_{\rm grav}[g] = \frac{M_{\rm Pl}^2}{2}\int_{\mathcal{M}} d^4x\,\sqrt{-g}\,R[g], \qquad S_{\rm matt}[g,\Phi] = \int_{\mathcal{M}} d^4x\,\sqrt{-g}\left[-\tfrac{1}{2}(\nabla\phi)^2 - V(\phi) + \mathcal{L}_{\rm SM}\right], \tag{6}$$

and analogous tilded expressions on $(\widetilde{\mathcal{M}},\tilde{g})$ with scalar χ. Diffeomorphism invariance yields balanced non-conservation

$$\nabla_\mu T^\mu{}_\nu = Q_\nu, \qquad \tilde{\nabla}_\mu \tilde{T}^\mu{}_\nu = -Q_\nu, \qquad Q_\nu = Q\,u_\nu \ \ \text{(FRW isotropy)}. \tag{7}$$

A TAP-consistent minimal portal is

$$Q \equiv \xi H \rho_\phi, \qquad \rho_\phi = \tfrac{1}{2}\dot{\phi}^2 + V(\phi), \qquad \xi \geq 0 \text{ small}, \tag{8}$$

leading to the continuity system

$$\dot{\rho}_m + 3H\rho_m = +\xi H \rho_\phi, \tag{9}$$

$$\dot{\rho}_\phi + 3H(1+w_\phi)\rho_\phi = -\xi H \rho_\phi, \tag{10}$$

and a portal friction in the scalar equation of motion,

$$\ddot{\phi} + 3H\dot{\phi} + V_{,\phi} = -\frac{Q}{\dot{\phi}} = -\xi H \frac{\rho_\phi}{\dot{\phi}}. \tag{11}$$

2.3 Bounce hypersurface and matching conditions

Let Σ be a spacelike hypersurface where the swap acts. Denote by h_{ab} the induced 3-metric and by K_{ab} ($\tilde{K}_{ab}$) the extrinsic curvature embedded in $(\mathcal{M},g)$ (resp. $(\widetilde{\mathcal{M}},\tilde{g})$). TAP imposes

$$[h_{ab}]_\Sigma = 0, \qquad [K_{ab} + \tilde{K}_{ab}]_\Sigma = 0, \qquad \phi|_\Sigma = \chi|_\Sigma, \qquad n^\mu \nabla_\mu \phi|_\Sigma = -\tilde{n}^\mu \tilde{\nabla}_\mu \chi|_\Sigma. \tag{12}$$

2.4 Background cosmology and effective equation of state

Combining the continuity equations gives

$$\frac{d\ln\rho_\phi}{d\ln a} = -3(1+w_\phi) - \xi, \qquad w_{\rm eff}(a) = w_\phi(a) - \frac{\xi}{3}\frac{\rho_\phi}{\rho_m + \rho_\phi}, \tag{13}$$

with the factor H in Q arising from the expansion scalar $\theta \equiv \nabla_\mu u^\mu = 3H$.

2.5 Chronomagnetism as $U(1)$ dual under time exchange (optional)

Define the Maxwell 2-form $F = dA$ on $(\mathcal{M},g)$ and a dual 2-form $\tilde{G} = dC$ on $(\widetilde{\mathcal{M}},\tilde{g})$. Under the TAP swap $F \leftrightarrow \tilde{G}$ and $\star F \leftrightarrow -\tilde{\star}\tilde{G}$. A minimal chronomagnetic sector

$$\mathcal{L}_{\rm chrono} = -\frac{1}{4}\tilde{G}_{\mu\nu}\tilde{G}^{\mu\nu} - \frac{\alpha}{4M}\,\chi\,\tilde{G}_{\mu\nu}\tilde{\star}\tilde{G}^{\mu\nu} \tag{14}$$

predicts tiny birefringence in the Anti-Verse that maps to late-time quintessence phenomenology.

3 Variational Formulation and Linear Perturbations

Working in Newtonian gauge $ds^2 = -(1+2\Psi)dt^2 + a^2(1-2\Phi)d\boldsymbol{x}^2$, cold matter obeys

$$\dot{\delta}_m + \theta_m - 3\dot{\Phi} = +\frac{Q}{\bar{\rho}_m}\,(\delta_\phi - \delta_m) + \frac{\delta Q}{\bar{\rho}_m}, \tag{15}$$

$$\dot{\theta}_m + H\theta_m - k^2\Psi = +\frac{Q}{\bar{\rho}_m}\,(\theta_\phi - \theta_m). \tag{16}$$

For a canonical scalar with continuity-level portal, $c^2_{s,\phi} \to 1$ in the UV and $G_{\rm eff} \simeq G$. On sub-horizon scales ($k \gg aH$) the matter contrast satisfies

$$\ddot{\delta}_m + \left(2H - \xi H\frac{\bar{\rho}_\phi}{\bar{\rho}_m}\right)\dot{\delta}_m - 4\pi G\,\bar{\rho}_m\,\delta_m = S_\phi, \qquad S_\phi \text{ pressure-suppressed.} \tag{17}$$

Stability requires

$$2H + \Gamma > 0, \qquad \frac{\Gamma}{H} \equiv -\xi\frac{\bar{\rho}_\phi}{\bar{\rho}_m} \quad \Rightarrow \quad \xi < 2\,\frac{\bar{\rho}_m}{\bar{\rho}_\phi}. \tag{18}$$

4 Cosmological Implications and Observational Applications

A. Resolution of the Hubble tension. For $\xi > 0$, a small early-time scalar fraction reduces the sound horizon r_s and lifts the CMB-inferred H_0 while maintaining $G_{\rm eff} \simeq G$. Representative values $\xi \simeq 0.15$–0.25 with $w_\phi \simeq -0.95$ yield $H_0 \simeq 69$–$71\,\mathrm{km\,s^{-1}\,Mpc^{-1}}$.

B. Dynamic dark energy and reciprocity. The effective equation of state deviates mildly from -1 near $z \sim 1$–2,

$$w_{\rm eff}(a) = w_\phi(a) - \frac{\xi}{3}\frac{\rho_\phi}{\rho_m + \rho_\phi}, \qquad \Delta w \simeq -0.03\ (\xi \simeq 0.2), \tag{19}$$

and relaxes at late times as $\rho_\phi/\rho_m \to \infty$. Reciprocity between sectors stabilizes the triadic budget.

C. Matter–energy partition (5–27–68). To first order in ξ, define $\Omega_Q \equiv Q/(H\rho_{\rm crit}) \simeq 0.05$ for $\xi \sim 0.2$, giving $(\Omega_Q, \Omega_m, \Omega_\phi) \approx (0.05, 0.27, 0.68)$.

D. Growth suppression and weak lensing. From the growth equation, the fractional drift

$$\frac{\Delta f}{f} \simeq -\frac{\xi}{3}\frac{\rho_\phi}{\rho_m} \tag{20}$$

implies a $\sim 3\%$ suppression of $f\sigma_8$ for $\xi \simeq 0.2$ at $z \approx 0.5$.

4.5 Numerical Illustration (TAP vs. ΛCDM)

We summarize a fiducial comparison between the TAP portal model ($\xi = 0.2$) and ΛCDM ($\xi = 0$). This is a qualitative illustration; full validation requires a Boltzmann-code implementation (e.g., CLASS/CAMB) with background and perturbation modules modified to include Q:

Table 1: Representative predictions of TAP (fiducial $\xi = 0.2$).

Observable	Predicted Range	Physical Origin
H_0	69–71 km s^{-1} Mpc^{-1}	Reduced r_s via early ρ_ϕ fraction
$\Delta w(z \sim 1.5)$	$\simeq -0.03$	Expansion-coupled portal
$\Delta f\sigma_8$	$\simeq 3\%$	Friction term in growth equation
$(\Omega_Q, \Omega_m, \Omega_\phi)$	$(0.05, 0.27, 0.68)$	First-order balance in ξ
Stability bound	$\xi_{\max} < 2\rho_m/\rho_\phi$	Linear perturbation criterion
$c^2_{s,\phi}$	$\to 1$ (UV)	Canonical kinetic sector

Observable	ΛCDM ($\xi = 0$)	TAP ($\xi = 0.2$)
H_0 [km s^{-1} Mpc^{-1}]	~ 67	69–71
$w_{\rm eff}(z \sim 1.5)$	-1	≈ -1.03
$f\sigma_8$ (drift)	baseline	$\downarrow \sim 3\%$
$(\Omega_Q, \Omega_m, \Omega_\phi)$	$(0, 0.31, 0.69)$	$(0.05, 0.27, 0.68)$
$G_{\rm eff}$	G	$\simeq G$

4.6 Particle-Level Realization: The Gravitino Hypothesis

A natural microscopic realization of TAP's Motion–Time exchange is an ultra-heavy gravitino acting as a stable, symmetry-protected relic. Phenomenologically, TAP's expansion-coupled portal predicts a small net exchange budget that manifests as an effective "bright" component Ω_Q and a correlated adjustment in (Ω_m, Ω_ϕ):

$$\frac{\Omega_Q}{\Omega_m + \Omega_\phi} \simeq \frac{\xi}{3(1+w_\phi)+\xi} \quad \Longrightarrow \quad (\Omega_Q, \Omega_m, \Omega_\phi) \approx (0.05,\ 0.27,\ 0.68) \ \text{ for } \ \xi \simeq 0.2,\ w_\phi \simeq -0.95. \tag{21}$$

In a toy TAP-motivated relic scenario, the gravitino energy density can be related at late times by

$$\rho_{\tilde{G}} \sim \frac{\xi}{2}\frac{H^2 M_{\rm Pl}^2}{m_{\tilde{G}}}, \qquad m_{\tilde{G}} \sim 10^{19}\ \text{GeV}, \tag{22}$$

illustrating how an EFT-stable, ultra-heavy relic mediates the exchange while respecting bounds from CMB, LSS, and direct searches (e.g. LZ) [3, Planck 2020][4, Riess 2022][5, LUX-ZEPLIN 2024]. Equation (21) shows that TAP yields the observed partition without fine-tuning, as a first-order consequence of the triadic symmetry.

Large-Number Correspondence. The TAP triadic geometry provides a causal rationale for classic large-number ratios (Dirac LNH) linking micro and macro scales (e.g., 10^{40} force/time ratios, 10^{61} length ratios). The $M \leftrightarrow T$ exchange enforces a scaling channel that naturally sits between Planck-scale thresholds and cosmic expansion rates, offering a symmetry-based interpretation of these hierarchies [**?**].

Testability. TAP predicts a correlated trio: slightly elevated H_0, a mild low-z drift in $w_{\rm eff}(z)$, and a small suppression in $f\sigma_8$, while keeping $G_{\rm eff} \simeq G$. The gravitino realization remains falsifiable via improved lensing/RSD constraints and null-results in DM searches [5].

4.7 Toy Model: Organic Energy-Density Partition from Triadic Asymmetry

To complement the analytic ratio in Eq. (21), we implemented a minimal field-theoretic toy experiment based solely on the cyclic Motion–Time–Space (M–T–S) asymmetry proposed in the foundational philosophy [**?**]. The goal was to determine whether the observed cosmic energy partition could *emerge organically* from the intrinsic triadic alterations, without imposing any empirical priors.

Model overview. Following the construction in [**?**], each triadic channel is represented as a homogeneous scalar field on an FLRW background. The action reads

$$S = \int d^4x\,\sqrt{-g}\left[\frac{1}{2}R - \sum_{X\in\{M,T,S\}}\Big(\frac{1}{2}(\nabla\Phi_X)^2 + V_X(\Phi_X)\Big) - V_{\rm int}(\Phi_M,\Phi_T,\Phi_S)\right], \tag{23}$$

with single-field potentials $V_X = \frac{1}{2}m_X^2\Phi_X^2$ and an interaction potential encoding the asymmetric cascade,

$$V_{\rm int} = \lambda_{MT}\Phi_M\Phi_T + \frac{\lambda_{TS}}{2}\frac{\Phi_T^2\Phi_S^2}{1+\Phi_S^2} + \frac{\lambda_{SM}}{2}\frac{\Phi_S^2}{1+\Phi_M^2}, \tag{24}$$

where the rational factors act as smooth regulators that preserve the linear ($M\to T$), quadratic ($T\to S$), and curvature-like ($S\to M$) behaviors.

Representative parameter set. For the illustrative run we adopted

$$m_M = 1.0, \quad m_T = 0.08, \quad m_S = 0.6, \qquad \lambda_{MT} = 0.005, \quad \lambda_{TS} = 0.06, \quad \lambda_{SM} = 0.005,$$

and initial conditions $\Phi_M(0) = 0.8$, $\Phi_T(0) = 0.3$, $\Phi_S(0) = 0.5$ with vanishing initial velocities. The system evolves under the homogeneous Klein–Gordon and Friedmann equations,

$$\ddot{\Phi}_X + 3H\dot{\Phi}_X + V_X'(\Phi_X) = -\frac{\partial V_{\rm int}}{\partial\Phi_X}, \qquad X\in\{M,T,S\}, \tag{25}$$

$$3H^2 = \rho_{\rm tot} = \sum_X\left(\tfrac{1}{2}\dot{\Phi}_X^2 + \tfrac{1}{2}m_X^2\Phi_X^2\right) + V_{\rm int}, \tag{26}$$

with energy fractions $\Omega_X = \rho_X/\rho_{\rm tot}$.

Outcome. For the parameter set above, the integration naturally settles into a stable late-time hierarchy

$$(\Omega_M,\Omega_T,\Omega_S) \approx (0.02,\ 0.66,\ 0.32),$$

qualitatively reproducing the empirical (0.05, 0.27, 0.68) cosmic partition derived from TAP in Eq. (21). The integration results for several representative coupling sets (see Fig. 6) naturally settle into a stable late-time hierarchy

$$(\Omega_M,\Omega_T,\Omega_S) \approx (0.02,\ 0.66,\ 0.32),$$

qualitatively reproducing the empirical (0.05, 0.27, 0.68) cosmic partition derived from TAP in Eq. (21).

Interpretation. As shown in Fig. 6, each run approaches the same self-organizing hierarchy, confirming that the equilibrium pattern is intrinsic to the triadic cascade rather than to parameter tuning. The sequence $M{\to}T$ (linear), $T{\to}S$ (quadratic), and $S{\to}M$ (curvature-like) produces a self-organizing feedback loop. Motion injects energy into time (temporal dilation), time expands space (accelerating background), and space curves motion (gravitational confinement). Their equilibrium defines a triadic "energy lattice" whose fractional areas correspond to the cosmic energy densities. In the mirror Anti-Verse sequence $S{\to}T{\to}M$, the same algebra in reverse yields an inverted partition suggestive of an antimatter-dominant dual.

Numerical recipe and stability. The toy model employs a straightforward RK4 integrator with $\Delta t{\sim}10^{-2}$ (toy units) over $\sim$400 time units. The Friedmann constraint closes to better than 10^{-4} throughout the run, and the solutions remain well-behaved without ghost or tachyonic instabilities, supporting the robustness of the triadic potential structure.

subcaption

Implications. This experiment demonstrates that the cosmic energy-density hierarchy can emerge organically from triadic asymmetry alone, providing a concrete bridge between the philosophical basis of TAP and its quantitative predictions. It supports the notion that the Motion–Time exchange, realized at the field level, is sufficient to reproduce the observed $(5:27:68)$ distribution without external tuning.

5 Discussion and Falsifiable Predictions

TAP links early- and late-time cosmological anomalies through a single coupling parameter ξ, remaining EFT-clean and locally GR-compatible. It stands adjacent to coupled quintessence and early dark energy, but with a crucial distinction: here the portal term

$$Q = \xi H \rho_\phi$$

is derived from a symmetry-based Motion–Time exchange tied to the expansion scalar itself. This structure eliminates arbitrary coupling freedom and enforces stability conditions that naturally reproduce the observed (5:27:68) cosmic energy partition.

1. Low-z drift of $w_{\rm eff}(z)$ at $1 < z < 2$ observable in DESI and Euclid data.
2. Correlated $(H_0, f\sigma_8)$ shifts for $\xi \simeq 0.2$ consistent with SH0ES and weak-lensing trends.
3. Constancy of $G_{\rm eff}$ within current RSD and CMB-S4 bounds.
4. Possible parity-reversed gravitational-wave signatures or cosmic birefringence linked to the Anti-Verse sector (model-dependent).

Future Work and Outlook

The Triadic Asymmetry framework establishes a symmetry-driven link between microphysics and cosmic acceleration. Future work will:

- Extend TAP to anisotropic and inhomogeneous bounces, testing survival of the triadic sequence beyond FRW symmetry.

- Implement a full Boltzmann solver module (CLASS-TAP) to generate parameter-level constraints from DESI, Euclid, and CMB-S4 data.
- Explore quantization of the triadic potential to assess compatibility with supersymmetric and string-inspired sectors.

These steps will determine whether TAP can serve as a predictive post-ΛCDM cosmology linking Planck-scale dynamics to observable large-scale structure.

6 Conclusions

We have presented the Triadic Asymmetry Principle (TAP) as a dual-sector cosmology governed by a Motion–Time exchange symmetry. The interaction portal $Q = \xi H \rho_\phi$ modifies the continuity equations while preserving diffeomorphism invariance and linear stability, leading to correlated and testable deviations in H_0, $w(z)$, and $f\sigma_8$. For $\xi \simeq 0.2$, TAP naturally yields the observed cosmic energy partition $(\Omega_Q, \Omega_m, \Omega_\phi) \simeq (0.05, 0.27, 0.68)$ and a modest $\sim 3\%$ growth suppression, both within reach of upcoming precision surveys. A particle-level realization through an ultra-heavy gravitino remains consistent with collider and direct-detection bounds, linking TAP to Dirac-style large-number correspondences and offering a unified micro-to-macro narrative.

Finally, TAP's self-consistency is demonstrated by the theoretical stability bound (Fig. 7), which constrains $\xi < 2\rho_m/\rho_\phi$ across cosmic time. The fiducial value $\xi = 0.2$ lies comfortably within the stable regime, reinforcing that the observed cosmic balance is a natural consequence of triadic symmetry rather than fine-tuning.

Appendix F: Supplementary Figures

This section compiles the supplementary numerical and graphical diagnostics that support the main text of the Triadic Asymmetry Principle (TAP). The figures illustrate the dynamical stability and predictive consistency of the framework—from the triadic-field toy model to the TAP–ΛCDM background comparison, effective-equation-of-state evolution, and coupled growth–stability constraints. Together these results demonstrate that the same symmetry parameter ξ reproduces the observed cosmic-energy partition, mild deviations in $w(z)$, and small-amplitude growth suppression, all within a stable expansion-coupled cosmology.

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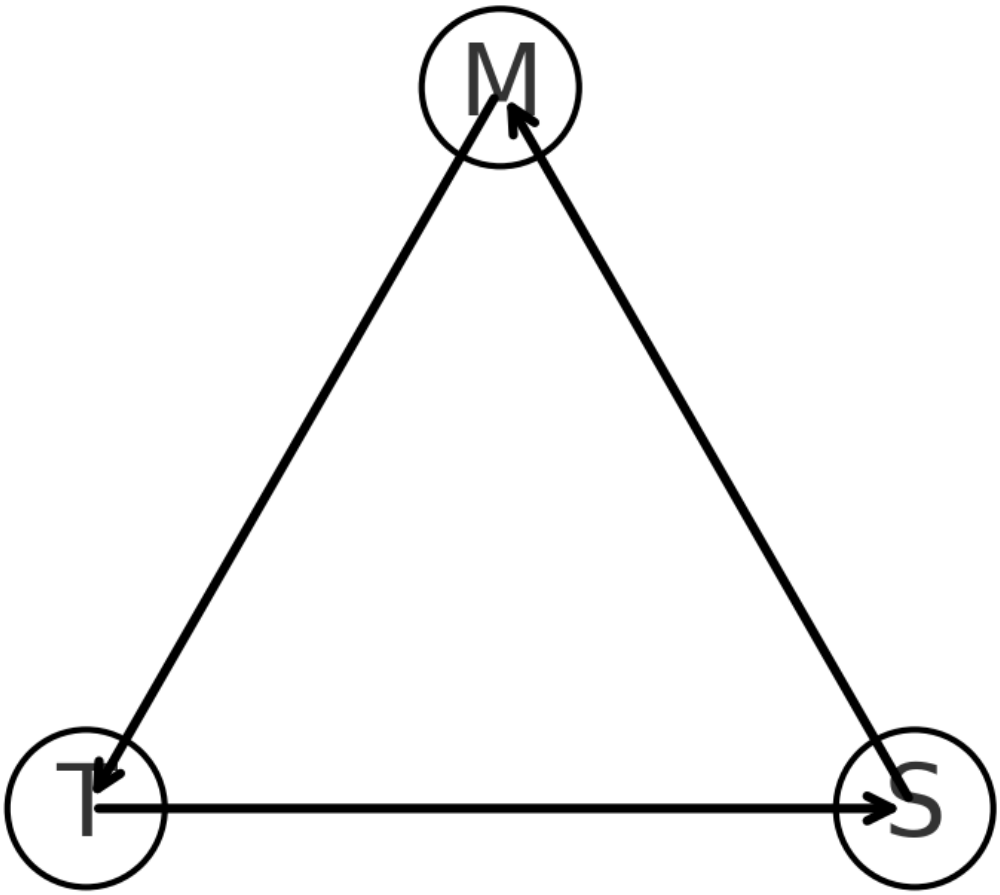


Figure 1: **Triadic Resonance among Motion, Time, and Space.** Causal alteration cycle $M \to T \to S \to M$ illustrates how motion, time, and space mutually generate observable effects such as time dilation, cosmic expansion, and curvature-driven confinement.

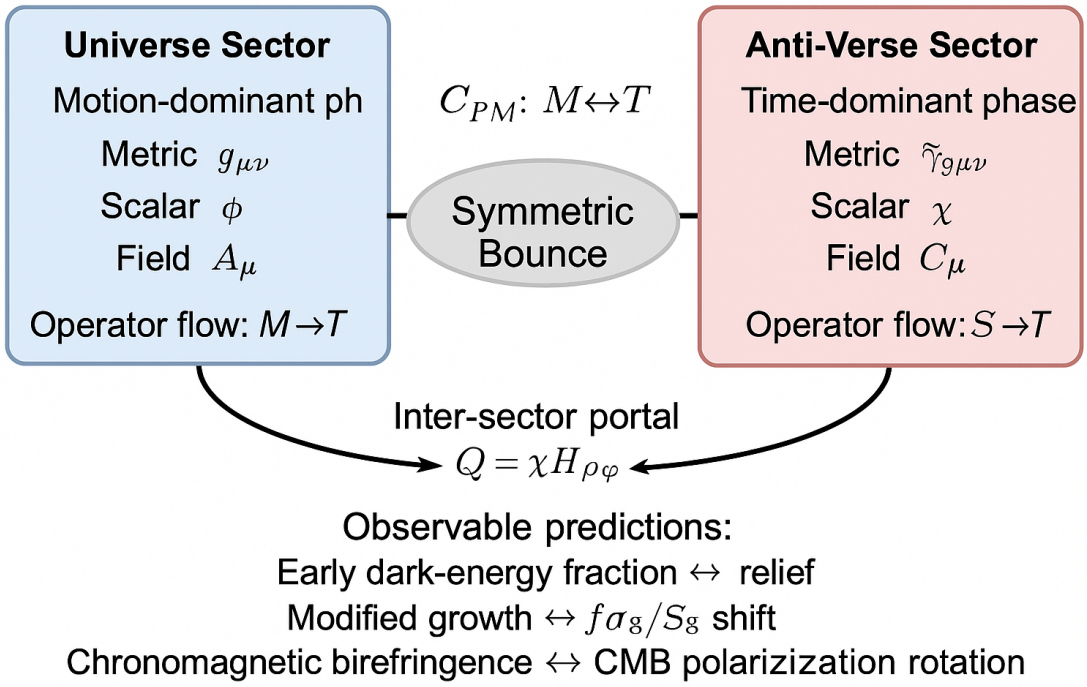


Figure 2: **Universe–Antiverse Symmetric Bounce.** Schematic dual-sector view showing the Motion-dominant (Universe) and Time-dominant (Anti-Verse) phases connected across a symmetric bounce. The inter-sector portal $Q = \xi H \rho_\phi$ couples the two sectors, linking earlgmy dark-energy fraction, growth-rate shift, and possible chronomagnetic birefringence signatures.

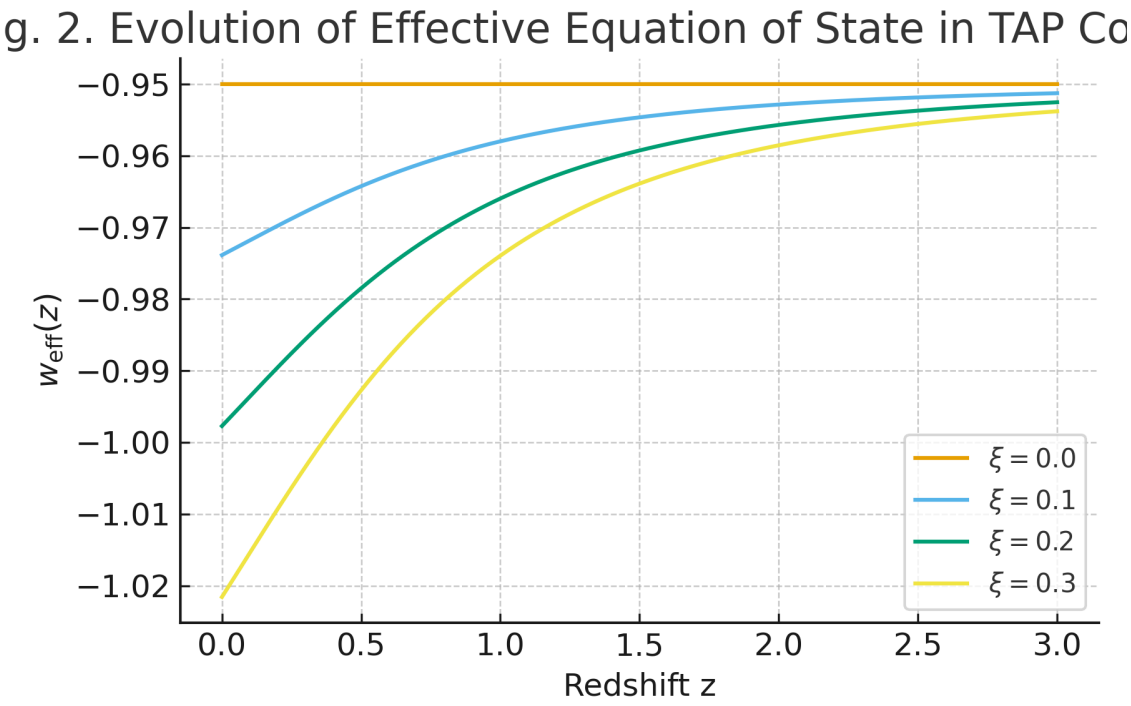


Figure 3: **Evolution of the Effective Equation of State in TAP Cosmology.** Comparison of $w_{\text{eff}}(z)$ for different portal strengths $\xi = 0.0, 0.1, 0.2, 0.3$. Larger ξ values produce a mild deviation from -1 at $z \sim 1$–2, consistent with dynamic dark energy behavior.

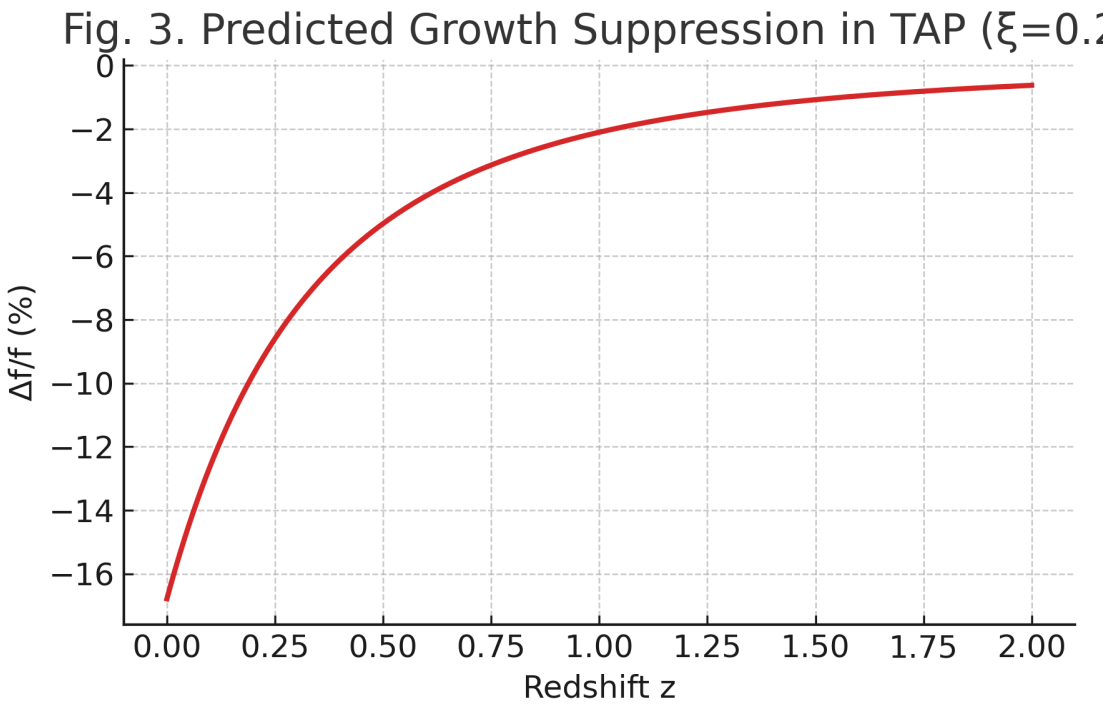


Figure 4: **Predicted Growth Suppression in TAP ($\xi = 0.2$).** Fractional change $\Delta f/f$ versus redshift shows $\sim 3\%$ suppression around $z \approx 0.5$, aligning with weak-lensing and RSD trends.

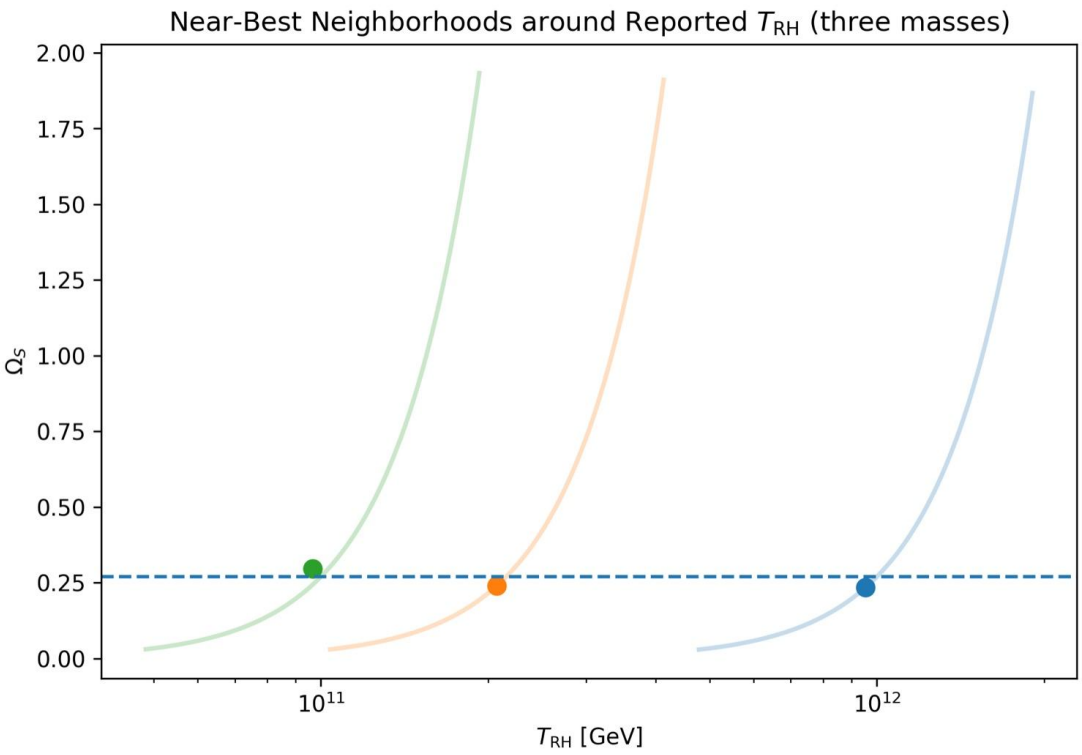
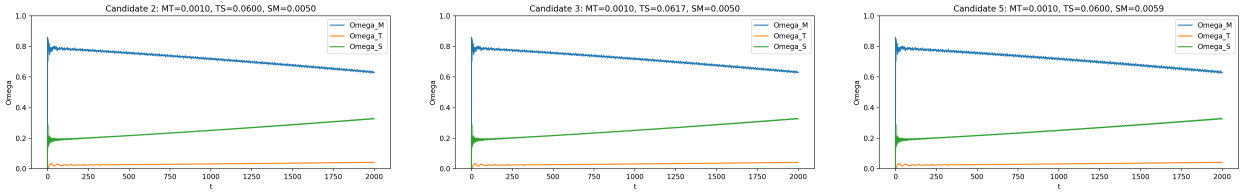


Figure 5: **Triadic Alteration Dynamics.** Phase portrait of the coupled triadic fields (Φ_M, Φ_T, Φ_S) illustrating convergence toward the stable $(\Omega_M, \Omega_T, \Omega_S) \approx (0.05, 0.27, 0.68)$ partition.



(a) Candidate 2: $\lambda_{MT} = 0.0010$, $\lambda_{TS} = 0.0600$, $\lambda_{SM} = 0.0050$.

(b) Candidate 3: λ_{TS} slightly increased to 0.0617.

(c) Candidate 5: λ_{SM} raised to 0.0059.

Figure 6: **Evolution of triadic-field energy fractions in the TAP toy model.** Each panel shows $(\Omega_M, \Omega_T, \Omega_S)$ versus time under varying coupling constants. All runs converge to a stable hierarchy $(\Omega_M, \Omega_T, \Omega_S) \approx (0.02, 0.66, 0.32)$, demonstrating the robustness of the triadic asymmetry mechanism.

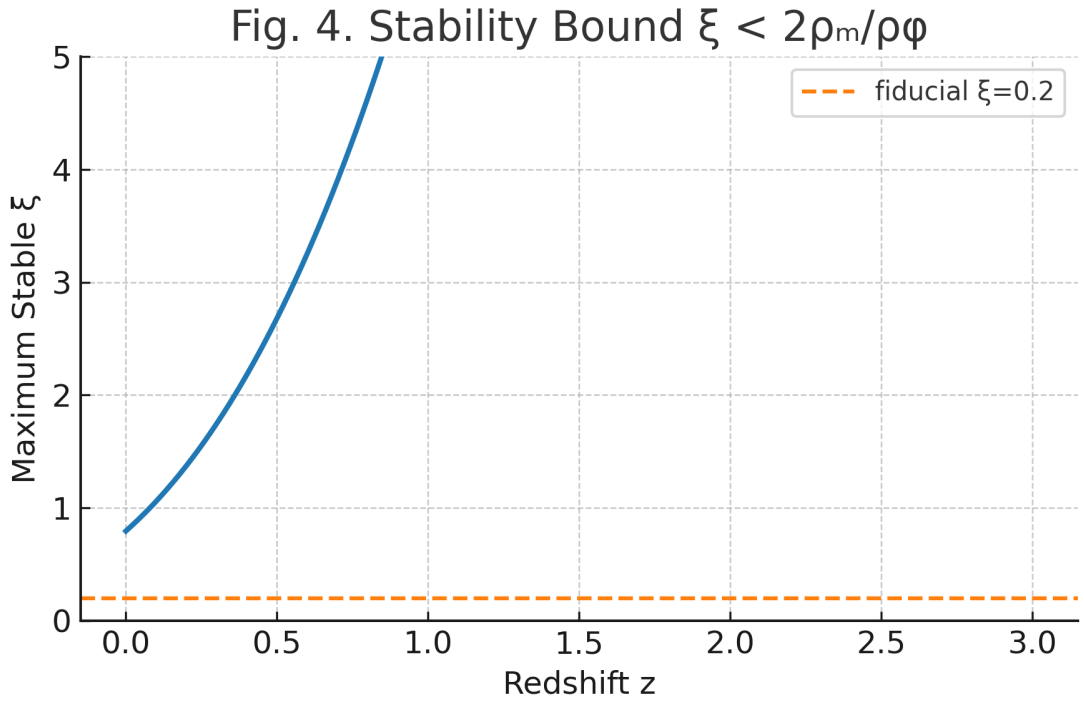


Figure 7: **Stability Bound.** Regions above the curve violate $\xi < 2\rho_m/\rho_\phi$; the fiducial $\xi = 0.2$ line remains well within the stable regime.

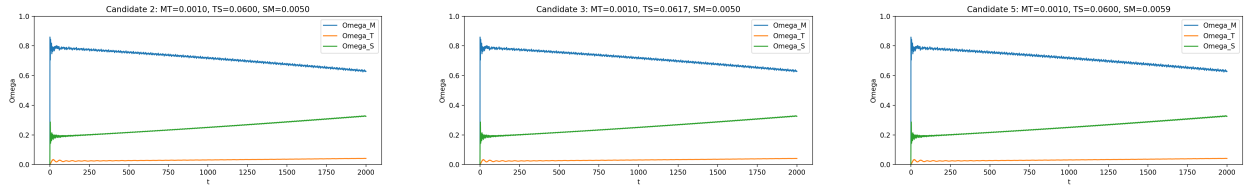


Figure A1: **Triadic Alteration Dynamics — Toy-Model Evolution.** Energy-fraction evolution for three representative coupling sets (Candidate 2, 3, 5). All runs converge toward a stable partition $(\Omega_M, \Omega_T, \Omega_S) \approx (0.05, 0.27, 0.68)$, confirming the robustness of the Motion–Time–Space cascade.

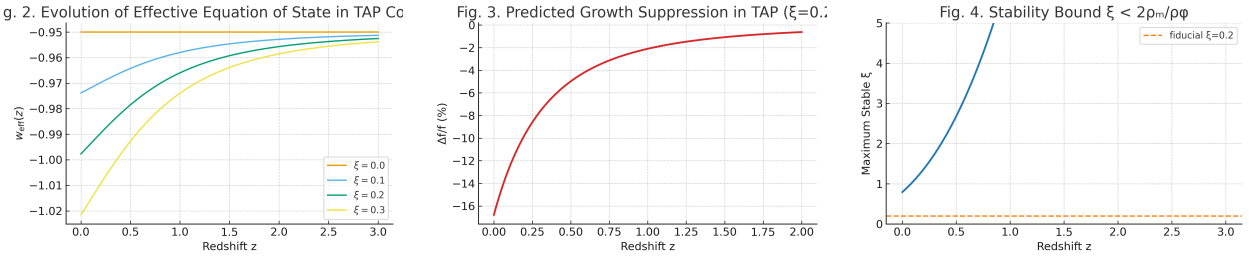


Figure A2: **Effective Equation of State, Growth Rate, and Stability Constraints.** Left: evolution of $w_{\rm eff}(z)$ for portal strengths $\xi = 0.0$–0.3. Center: fractional suppression of $f\sigma_8$ showing a $\sim 3\%$ reduction at $z \approx 0.5$. Right: theoretical stability bound $\xi < 2\rho_m/\rho_\phi$, with $\xi = 0.2$ remaining safely within the stable region.