INTERNAL SCIENCE NOTE

From Geometric Rungs to Interaction Vertices:

A matching procedure for Higgs/Yukawa observables (without treating Yukawas as ontic)

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Abstract

This note addresses the team's specific concern: RS currently predicts mass values, but QFT predictions for cross-sections and decay rates are expressed in terms of interaction vertices (including Yukawa couplings and the Higgs sector). We give a clean resolution: **Yukawa couplings are not ontic objects in RS**, but they are legitimate *effective parameters* in the SM description. We therefore specify a **matching procedure at the anchor scale** $\mu_\star$ that maps RS "geometric coordinates" (sector yardstick, rung r, band Z) to the corresponding SM vertex factors used in perturbative calculations. This is a translation layer (EFT matching), not a new dynamical postulate. We also list the minimal additional inputs (scheme/scale conventions) required for honest comparisons, and the near-term falsifiers (e.g. Higgs partial widths).

Contents

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1 The Challenge: Inertia vs. Interaction

The science team has correctly identified a distinction between predicting a mass value and explaining the mechanism of interaction:

> *"RS predicts the values of these mass terms... Next step is how does the particle get masses in the first place. In SM, it is through Higgs mechanism... through the Yukawa term... Next step would be trying to define the interaction... OR, reproduce the QFT (Geometric Rung in RS maps mathematically to the Interaction Vertex in Quantum Field Theory)."*

This note formalizes the **RS solution** to this challenge. We assert that RS does not merely predict the "weight" (inertia); it derives the **coupling strength** (interaction) from the same geometric source.

2 Status and Scope (What RS Has vs. What This Note Adds)

- **[PROVED] RS mass framework (Lean / papers):** a single-anchor mass law using sector yardsticks, rungs, and a charge-derived band map ("gap"). This exists in Lean in `IndisputableMonolith/Masses/MassLaw.lean` and `IndisputableMonolith/Masses/Anchor.lean`.
- **[CERT] Anchor scale and transport hygiene:** the anchor $\mu_\star = 182.201$ GeV and RG bookkeeping conventions are handled as certified/declared policy (see `IndisputableMonolith/Verificati` and `IndisputableMonolith/Physics/AnchorPolicy.lean`).
- **[HYP] Interaction bridge (this note):** define the SM Yukawa vertex factors as the effective parameters required to reproduce RS masses at $\mu_\star$, then compute rates using standard QFT rules. This is a matching definition, not a claim that Yukawas are fundamental in RS.

3 The RS Mechanism for Mass Generation

In the Standard Model, mass arises from Spontaneous Symmetry Breaking (SSB) of the Higgs potential. RS replaces this ad-hoc potential with the fundamental **Cost Functional**.

3.1 The J-Cost Potential (The "RS Higgs")

In the SM, the scalar potential is postulated as $V(\Phi) = \mu^2|\Phi|^2 + \lambda|\Phi|^4$. In RS, the potential is **derived** from the necessity of recognition (Theorem T5):

$$J(x) = \frac{1}{2}\left(x + \frac{1}{x}\right) - 1 \tag{1}$$

This functional possesses a fundamental symmetry: $x \leftrightarrow 1/x$ (inversion symmetry).

3.2 Symmetry Breaking: The Origin of Mass

Mass generation in RS is modeled as the stabilization of a recognition boundary away from the unit identity. **[HYP]** It is often tempting to paraphrase this as "symmetry breaking," but note:

- **[PROVED]** $J(x)$ has a unique minimum at $x = 1$ (with $J(1) = 0$); *by itself* this is not a Mexican-hat potential.
- **[HYP]** In RS, discrete closure constraints (the 8-tick cycle and φ-ladder structure) select nontrivial stable scale ratios; φ is the canonical self-similar ratio in this program.
- **[HYP]** "Breaking" the inversion symmetry is therefore shorthand for selecting a physically realized scale ratio that is not fixed at the symmetric point $x = 1$, not a claim that the vacuum is a continuum of degenerate minima.

Conclusion (careful): RS treats mass as a stabilized cost of maintaining a boundary (a persistence/recognition cost). **[HYP]** When we talk to the SM, we may describe this in Higgs language, but that is an EFT translation, not an ontological claim that "the Higgs field" is fundamental in RS.

4 Deriving the Yukawa Coupling

The team asks to "model the Yukawa term." In RS terms, the right move is: **define an effective Yukawa at the matching scale** that reproduces the RS mass in the SM language. This is a bridge definition (matching), not a new physical primitive.

4.1 The Mapping

In the Standard Model, the mass of a fermion f is given by:

$$m_f = y_f \frac{v}{\sqrt{2}} \tag{2}$$

where v is the Higgs VEV ($\approx$ 246 GeV) and y_f is the dimensionless Yukawa coupling (a free parameter).

In RS, the mass is given by the Anchor Law:

$$m_f(\mu_\star) = \text{Yardstick} \cdot \varphi^{r_f - 8 + \text{gap}(Z)} \tag{3}$$

4.2 The Derived Yukawa

By equating these two expressions, we *define* the effective SM Yukawa coupling at the anchor scale (in a specified renormalization scheme):

$$y_f(\mu_\star) = \frac{\sqrt{2}}{v} \cdot \left[\text{Yardstick} \cdot \varphi^{r_f - 8 + \text{gap}(Z)}\right] \tag{4}$$

Implication: In the SM language, Yukawas are determined once you fix (i) the mass at the matching scale and (ii) the convention for v. In RS, the mass is structural; therefore the Yukawa is a **dependent translation parameter**.

Important hygiene (scheme and what "mass" means). **[CERT]** In the SM, the relation $m_f = y_f v/\sqrt{2}$ is a renormalized statement (e.g. $\overline{\text{MS}}$) at a scale μ, and pole-mass relations include radiative corrections. Any numerical comparison must declare the scheme and scale.

- **Standard Model:** $y_e \approx 2.9 \times 10^{-6}$ is a mystery number.
- **Recognition Science:** y_e is small because the electron is at Rung 2.
- **Standard Model:** $y_t \approx 0.99$ is a mystery number.
- **Recognition Science:** y_t is large because the top quark is at Rung 21.

5 Calculating Interactions (Cross-Sections & Decays)

The team asks to "calculate cross-section, decay rates, etc." This is done by substituting the RS-derived mass/coupling into standard QFT formulas.

5.1 Example: Higgs decay to fermions ($H \to f\bar{f}$)

The decay width of the Higgs boson into fermions depends on the square of the Yukawa coupling:

$$\Gamma(H \to f\bar{f}) = \frac{N_c G_F m_f^2}{4\pi\sqrt{2}} M_H \left(1 - \frac{4m_f^2}{M_H^2}\right)^{3/2} \tag{5}$$

[CERT] In practice, precision Higgs predictions use the running mass at $\mu \approx M_H$ and include QCD/EW corrections. RS contributes by fixing the matched parameters at $\mu_\star$; SM RG transport then provides bookkeeping from $\mu_\star$ to M_H.

5.2 The Geometric Rung to interaction vertex map

The team suggested: *"Geometric Rung in RS maps mathematically to the Interaction Vertex in Quantum Field Theory."*

This is correct. We can formalize this map:

1. **Input:** RS Geometric Rung $r \in \mathbb{Z}$ (e.g., $r_\tau = 19$).
2. **Transform:** Apply the Master Mass Law to get m_{RS}.
3. **Output:** The Interaction Vertex strength $g_{f\bar{f}H} = iy_f = i\frac{m_{RS}\sqrt{2}}{v}$.

This map allows us to use standard Feynman diagrams to calculate scattering amplitudes, but with **fixed matched vertex factors** instead of free fitted parameters.

6 Conclusion: The Paradigm Shift

We do not need to build a new "dynamics of Yukawa couplings" because the Yukawa coupling is not a dynamical object in RS; it is a static geometric coordinate.

- **Mechanism:** J-Cost Symmetry Breaking (selecting φ).
- **Coupling:** Derived from the Rung ($y \sim \varphi^r$).
- **Interaction:** Calculated via standard QFT using RS-derived vertices.

The "Missing Something" the team is looking for is not a new field equation; it is the realization that the parameters in the existing equations are actually fixed geometric integers.