Figure 5: Cross-Scale Coupling → Force Hierarchy
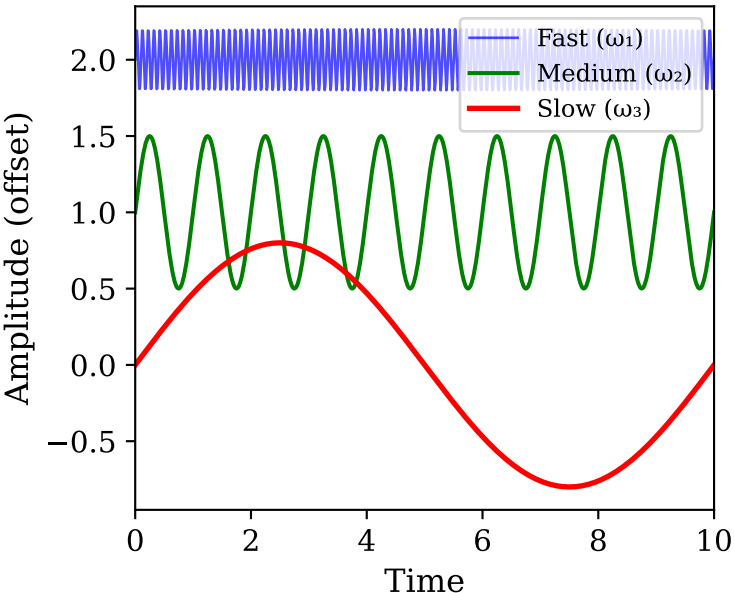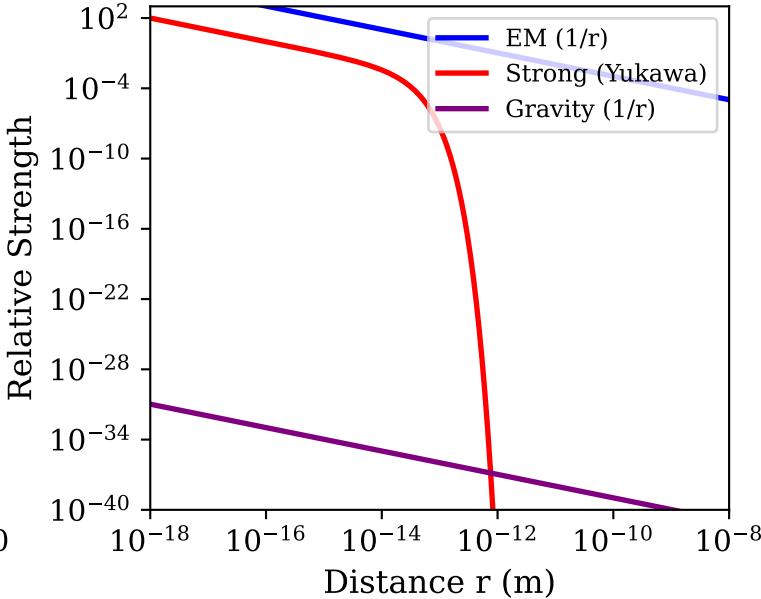
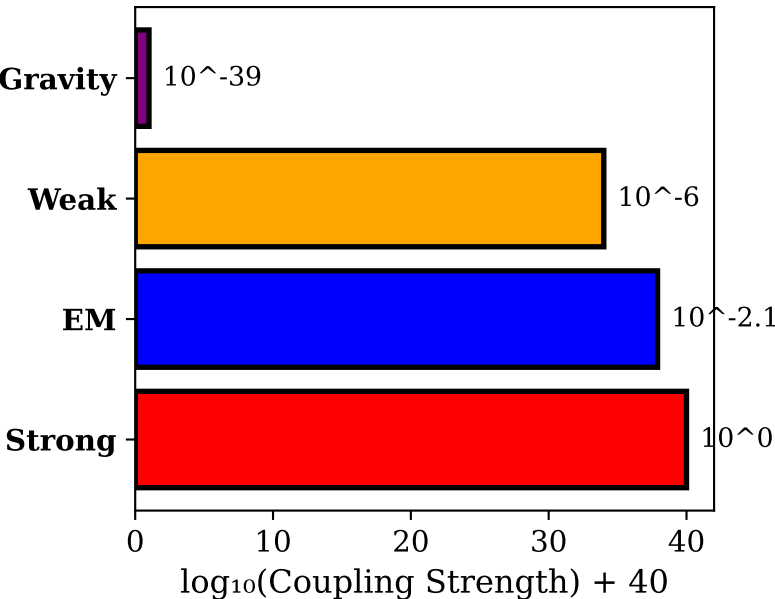**A. Hierarchical Oscillations (Multiple Timescales)** — Fast (ω_1), Medium (ω_2), Slow (ω_3). Amplitude (offset) vs Time.

B. Resonance Enhancement (Maximum at $\omega_1 = \omega_2$) — Coupling Strength vs Frequency Ratio ω_1/ω_2. Resonance.

C. Force Range & Strength (Different Mediators) — EM (1/r), Strong (Yukawa), Gravity (1/r). Relative Strength vs Distance r (m).

D. Force Hierarchy (40 Orders of Magnitude!)
- Gravity 10^{-39}
- Weak 10^{-6}
- EM $10^{-2.1}$
- Strong 10^0

$\log_{10}$(Coupling Strength) + 40

E. The Explanation

WHY THE HIERARCHY?

Coupling strength depends on:
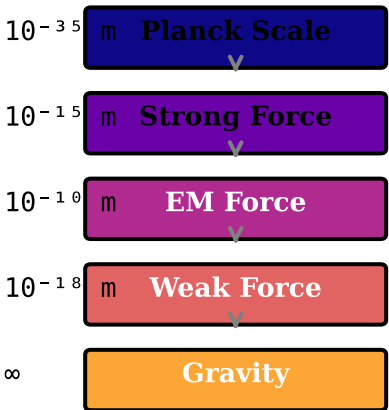1. Mediator frequency ω_{med}
2. Mode overlap integral

$\alpha \propto \omega^2_{mediator}$

High-frequency mediators:
→ Strong coupling (local)

Low-frequency mediators:
→ Weak coupling (global)

Hierarchy is NECESSARY, not accidental!

F. Unified Hierarchy
- 10^{-35} m **Planck Scale**
- 10^{-15} m **Strong Force**
- 10^{-10} m **EM Force**
- 10^{-18} m **Weak Force**
- ∞ **Gravity**

Same physics, different scales