1 Mapping Standard Model Particles to SST Knot Structures

In Swirl–String Theory (SST), each elementary particle is represented by a quantized knotted vortex loop in an underlying æther-like fluid. The knot type and its symmetries encode the particle's quantum numbers (mass, charge, chirality, *etc.*) [**?**, **?**]. The canon adopts the following taxonomy:

- **Unknotted loops** $\rightarrow$ bosons (force carriers).
- **Torus knots** $\rightarrow$ leptons (charged states are chiral torus knots).
- **Chiral hyperbolic knots** $\rightarrow$ quarks.
- **Amphichiral (mirror-symmetric) knots** $\rightarrow$ neutral "dark" states (e.g., neutrinos or other non-EM–interacting excitations).

Below we map the SM content—three generations of quarks and leptons, plus gauge bosons—onto their SST vortex–knot representatives, following the canonical rules and the helicity/mass analyses.

1.1 Leptons: Torus Knots and Amphichiral Hyperbolic Knots

Charged leptons (e^-, μ^-, τ^-). Each charged lepton is identified with a prime **torus knot** $T(2, 2k+1)$, reflecting broken mirror symmetry (consistent with nonzero electric charge). The canonical assignments are:

$$e^- \leftrightarrow 3_1 \quad \text{(trefoil)}, \qquad \mu^- \leftrightarrow 5_1 \quad \text{(cinquefoil)}, \qquad \tau^- \leftrightarrow 7_1 \quad \text{(septfoil)},$$

with $5_1 = T(2,5)$ and $7_1 = T(2,7)$ [**?**, **?**]. Increasing winding/twist raises the solitonic energy, tracking the $e:\mu:\tau$ mass hierarchy. In the SST invariant-mass model, (e, μ) calibrate the parameters; τ then follows once the knot length and layer are fixed [**?**]. These knots are reversible (two orientations, particle/antiparticle) but not mirror-symmetric—consistent with a unique charge sign.

Neutral leptons (ν_e, ν_μ, ν_τ). Electrically neutral, weakly interacting states are assigned to **amphichiral hyperbolic knots**, i.e., non-torus knots identical to their mirror image. The canonical pins are

$$\nu_e \leftrightarrow 4_1 \quad \text{(figure-eight)}, \qquad \nu_\mu \leftrightarrow 6_3, \qquad \nu_\tau \leftrightarrow 8_3,$$

all amphichiral with high discrete symmetry [?]. In the SST helicity classifier, such amphichiral controls yield $a_{SST} \approx -0.5$ [?], matching the absence of EM charge and the near-perfect mirror balance. Higher crossing number modestly increases hyperbolic volume and thus mass, aligning with the observed neutrino hierarchy.

1.2 Quarks: Chiral Hyperbolic Knots (Confined Vortices)

Quarks are represented by **chiral, non-torus (hyperbolic) knots**. Chirality and geometric complexity (crossings, writhe) correlate with larger solitonic energy and reduced stability, mirroring the SM mass/lifetime trends [?].

Up quark (u). The canonical representative is 5_2 [?]. It sits near the amphichiral band—its helicity index $a_{SST} \approx -0.490$—indicating mild chirality. The hyperbolic complement volume anchors hadronic scaling, with

$$\mathcal{V}_{5_2} = 2.8281.$$

Down quark (d). Mapped to 6_1, which exhibits stronger chiral asymmetry with $a_{SST} \approx -0.523$ [?]. Its larger hyperbolic volume,

$$\mathcal{V}_{6_1} = 3.1639,$$

supports a higher mass contribution than u [?]. In nucleons, the triplet of quark knots (e.g., uud for p; ddu for n) forms a linked, metastable configuration consistent with confinement; the total hadronic scale follows from the sum of constituent volumes/topology [?].

Second and third generations (c, s, t, b). Higher generations arise from increased knot complexity (additional layers/winding or higher-crossing chiral analogs of the first-generation representatives) [?]. For example, a chiral 8-crossing knot in the u-family (e.g., 8_{19}) is a natural charm candidate, while a strongly chiral 9-crossing analog fits the strange sector [?]. The top and bottom correspond to still higher-writhe, high-volume chiral knots (order ≥ 10 crossings), with the top's extreme energy rendering it only barely metastable (rapid weak decay).

1.3 Gauge Bosons and Related Excitations: Unknots and Links

Photon (γ). A **trivial knot** (unknot): a closed loop supporting massless swirl-waves—no chirality, no charge—consistent with the photon's quantum numbers [?].

W and Z bosons. Massive, short-lived excitations interpreted as transiently twisted/linked vortex loops. Charged $W^{\pm}$ correspond to small chiral deformations; the neutral Z to an achiral excitation. Their lack of topological protection matches their brief lifetimes [?].

Gluons (g). Modeled as flux-tube excitations linking quark knots—Hopf-linked loops or twisted bridges confined within hadrons—capturing color confinement phenomenology [?].

Higgs (H^0). A radially excited unknot or a high-symmetry amphichiral knot (e.g., $12a_{1202}$) acting as a scalar mode [?].

1.4 Exotic and Composite Constructions

SST admits richer topologies:

- **Hopf link** (two linked unknots): mesonic analogs (quark–antiquark).
- **Borromean rings** (three mutually linked loops): baryonic analogs.
- **High-crossing amphichiral knots** (e.g., $12a_{1202}$, 15_{331}): candidates for neutral dark states or sterile neutrinos [?].

Summary. Within the SST canon, topology provides a one-to-one map to particle sectors: torus knots for charged leptons; amphichiral hyperbolic knots for neutrinos; chiral hyperbolic knots for quarks (with complexity tracking generation and mass); and unknotted/linked loops for gauge and composite excitations [?, ?, ?].