Unified Phase-Geometric Theory (UPGT): Synopsis

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Synopsis of the SU(2) Phase Geometry Model on the 3-Sphere

The Unified Phase-Geometric Theory (UPGT) presents a unified physical framework based on a single SU(2) phase field $U(x) \in SU(2)$ defined on four-dimensional spacetime. The field represents an intrinsic phase geometry whose values form a 3-sphere S^3, interpreted as the fundamental configuration space underlying all physical phenomena.

From an ontological standpoint, the theory considers the global SU(2) phase on the 3-sphere as the primary structure, while familiar properties such as inertia, charge, spin, gravitation, and quantization arise as natural consequences of its topology and dynamics. For mathematical consistency, the model employs the formalism of a nonlinear sigma model with a Skyrme-type stabilization term, where global closure of S^3 is not required explicitly but remains implicitly assumed.

The theory is characterized by two parameters: the *phase rigidity* κ and the *curvature coupling* α. All physical constants can be dimensionally, and in some cases numerically, expressed through these quantities and the global curvature radius R.

Foundations

The fundamental Lagrangian is given by

$$L = \tfrac{\kappa}{2}\mathrm{Tr}(J_\mu J^\mu) + \tfrac{\alpha}{4}\mathrm{Tr}([J_\mu, J_\nu]^2) - V(U), \quad J_\mu = U^{-1}\nabla_\mu U.$$

From this formulation, the energy–momentum tensor and field equations are derived. In the macroscopic limit, the Einstein equation emerges with the identification $G = c^4/\kappa$, indicating that gravitation originates from phase rigidity. Topological excitations on S^3 ($\pi_3(S^3) = \mathbb{Z}$) correspond to quantized matter states; thus, discrete charge, spin, and mass follow geometrically from the topology of the phase field.

Quantum behavior arises not from postulated quantization rules but from the compactness of the SU(2) manifold. The model thereby provides a continuous bridge between classical fields, quantum mechanics, and gravitation within a single geometric structure [3].

Atomic Physics

In the atomic domain [1], the atom is treated as a *resonant configuration of the global SU(2) phase*, not as a collection of independent particles. It represents a coherent SU(2) mode of the entire 3-sphere, where the nucleus and electronic shells are coupled oscillatory components of one unified field.

The Coulomb interaction on S^3 is derived geometrically:

$$V(\chi) = \frac{Z\alpha}{\pi R}(\pi - \chi)\cot\chi,$$

which in the flat-space limit yields $V(r) = Z\alpha/r - (Z\alpha/4)(r/R^2) + \ldots$. From this relation, the Rydberg constant and fine-structure scaling follow directly, without introducing external postulates.

Empirical atomic rules such as the Pauli exclusion principle, Hund's rule, Klechkowski orbital order, and Slater's screening principles arise as geometric consequences of SU(2) phase symmetry and the topology of allowed resonant modes on S^3. This unifies the description of atomic structure and chemical periodicity under a single geometric mechanism, providing a natural conceptual bridge from atomic physics to chemistry.

The model also predicts curvature-dependent corrections proportional to $(r/R)^2$ in atomic levels, suggesting a potential avenue for experimental verification through high-precision spectroscopy.

Cosmology

On cosmological scales [2], the radius of curvature $R(T)$ becomes a dynamic variable governed by the effective equation

$$\kappa\ddot{R} + \sigma R - \frac{\alpha}{R^3} + 3V_0R^2 = 0,$$

where V_0 denotes the vacuum phase potential. This framework yields stationary and oscillatory solutions compatible with observed cosmological parameters.

Within this model, the fundamental constants—the Planck constant $\hbar$, the vacuum energy density ρ_{vac}, and the gravitational constant G—are derived from combinations of κ, α, and R. Cosmological redshift and large-scale structure are interpreted as manifestations of global phase evolution on the 3-sphere, rather than spatial expansion. In the limit of slow curvature variation, the standard Friedmann equations are recovered as an effective approximation.

Interpretation and Scope

The SU(2) phase geometry model provides a unified view in which:

- Spacetime curvature, quantum discreteness, and gauge interactions share a common geometric origin.
- Matter and fields correspond to stable or resonant configurations of the same SU(2) phase field.
- Fundamental constants arise naturally from the geometry of the 3-sphere.

Rather than replacing quantum field theory or general relativity, the model supplies a *geometric substrate* from which both can be derived as effective limits.

Current Stage

The formalism is internally consistent and reproduces correct dimensional relations for known constants. Initial numerical estimates of atomic and cosmological parameters show encouraging agreement with observation. Further work focuses on quantization of the SU(2) field on S^3, higher-order atomic corrections, and refined cosmological fits using the same geometric parameters.

Summary

> The Unified Phase-Geometric Theory describes physical reality as an SU(2) phase geometry on the 3-sphere, where particles, fields, and spacetime curvature are different aspects of a single self-consistent structure.

It provides a conceptually simple, geometrically motivated alternative framework, consistent with established physics yet open to direct experimental and theoretical verification.

References

[1] Dmitry Shurbin. Unified phase-geometric theory (upgt): Atom. `https://doi.org/10.5281/zenodo.17369516`, October 2025. Published October 16, 2025.

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