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Control Number Signatures in the Fine-Structure and Strong Coupling Constants

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Abstract

This short communication shows that the utility of golden section control numbers, previously demonstrated in the computation of the fine-structure constant at low energy, α, and at the Z boson mass scale, $\alpha(M_z)$, extends to the non-Abelian Quantum Chromodynamics (QCD) coupling. Specifically, the strong coupling constant at the Z boson mass scale, $\alpha_s(M_z)$, is found to exhibit a corresponding control number signature within the same framework. The detection of control number signatures in α, $\alpha(M_z)$, and $\alpha_s(M_z)$ indicates that these control numbers may encode a recurring numerical-geometric structure associated with fundamental physical constants, suggesting that, while standard paradigms treat coupling constants as empirically derived quantities governed by quantum field renormalization, they may relate to geometric constraints of Platonic number systems.

Keywords

Fine-Structure Constant at Low Energy, Fine-Structure Constant at High Energies, Golden Section Control Numbers, Quantum Electrodynamics, Quantum Chromodynamics, Strong Coupling Constant, Z Boson

1. Introduction

In Quantum Electrodynamics (QED), the fine-structure constant (α) given as

$$\alpha = \frac{e^2}{4\pi\varepsilon_0 \hbar c} \tag{1}$$

where e is the electron elementary charge, ε_0 is the vacuum permittivity, $\hbar$

is the reduced Planck constant, and c is the speed of light, is the coupling constant for electromagnetism. It measures the strength of the electromagnetic force between elementary charged particles. By contrast, the strong coupling constant (α_s), expressed as a function of an energy scale Q^2, is given by

$$\alpha_s\left(Q^2\right)=\frac{4\pi}{\beta_0 \ln\left(Q^2/\Lambda^2\right)} \tag{2}$$

where $\beta_0 = 11-\frac{2}{3}n_f$, Λ is the QCD scale parameter, and n_f the number of active quark flavors. It quantifies the strength of the strong interaction between quarks and gluons, acting as the primary scaling parameter within the framework of Quantum Chromodynamics (QCD). Binding quarks into protons, neutrons, and nuclei, this force is central to QCD, a gauge field theory with symmetry group SU(3) [1] [2] cited by [3]. d'Enterria *et al.* (2024) [4] state that "α_s *sets the scale of the strength of the strong interaction, theoretically described by Quantum Chromodynamics* (*QCD*), *and is one of the fundamental parameters of the Standard Model* (*SM*) *of particle physics*."

Both α and α_s are experimentally determined fundamental dimensionless constants [5]-[12]. Ablat *et al.* (2026) [5] say, "*a precise and accurate determination of* $\alpha_s\left(Q\right)$ *and its dependence on the energy scale Q is of vital importance for the current precision-frontier program at the Large Hadron Collider* (*LHC*), *where vast amounts of data are being gathered and push the boundary of precision measurements to the next level*." The 2022 CODATA recommended value of α is $7.2973525643(11) \times 10^{-3}$ [13], approximately 1/137.036. This is the value of α at zero energy. From [14], the 2026 world average value for the strong coupling constant evaluated at the mass of the Z boson, $\alpha_s\left(M_z\right)$, is approximately 0.1180(9). This value is derived via perturbative QCD (pQCD) fits from deep-inelastic scattering, lattice QCD simulations, and hadronic decays of the τ lepton.

The fine-structure and strong coupling constants are running constants; that is, they depend on the energy scale probed through quantum renormalization group equations. They run in opposite directions: the fine-structure constant increases with increasing energy, while the strong coupling constant decreases with increasing energy. This property of the strong coupling constant is known as asymptotic freedom [15], discovered in 1973 by David Gross, Frank Wilczek, and David Politzer, which explains why high-energy quarks behave almost like free particles. In [16], the fine-structure constant at low energy, α, and at Z boson mass scale, $\alpha\left(M_z\right)$, is computed by subjecting golden section control numbers to the inverse square law. In this short communication we show that control number signatures exist not only in α and $\alpha\left(M_z\right)$, as shown in [16], but also in the strong coupling constant at the Z boson mass scale, $\alpha_s\left(M_z\right)$. Throughout this paper, a control number signature refers to the recurrence of specific control number structures in numerical representations or scaling relations associated with physical constants. The detection of these signatures in α, $\alpha\left(M_z\right)$, and $\alpha_s\left(M_z\right)$ reveals a hitherto unexplored facet of the very important number-theoretic interface between geometry and nuclear and particle physics, and is crucial to understanding the origin of these fundamental constants of nature. The ubiquity of the golden section $\varphi = \frac{1+\sqrt{5}}{2}$ in nature is extensively studied, see [17] [18]. Marples and Williams (2022) [17] state that, "*a remarkable number of apparently disparate natural phenomena can be linked to the golden ratio, and occurrences of this number may be found at multiple length scales, ranging from the galactic to the atomic. Some of these instances, such as planetary orbits, RR Lyrae stars, phyllotaxis, the ultimatum game, Ising chains and quasicrystals stem from the fact that the golden ratio is, in the sense of Hurwitz's theorem, the most difficult number to approximate using rational quotients.*"

2. Control Number Signatures in α and α_s

In the analysis of golden section quasigeometric sequences, specific integer values, known as control numbers, emerge as stability boundaries in trends [18]. Central to this framework is **Figure 1**, first presented in [18], and reproduced in [16], which illustrates Axiom 6.1 in [18], in which the regions (117 - 119) and (1130 - 1132) represent transitions in the chiral properties of quasigeometric sequences. Several instances of the appearance of 117 at bifurcation points are studied in [18]. Within this framework, the integer 117 emerges as the primary control number marking structural shifts in golden section quasigeometric sequences. The continued presence of 117 at bifurcation points in the theory of the golden section led Mamombe (2017) [18] to wonder whether it is by "*squared numerical coincidence*" that this number relates to the fine-structure constant. Rather than viewing the numerical proximity as a mere "squared" coincidence, the analysis examines how an inverse square operation tied to this foundational control root maps onto the fine-structure constant. When evaluated through an inverse square relation, modified scaling led to the formulation of the expression

$$\alpha \approx 10^2 \left(\frac{1}{117.0623647} \right)^2 \approx \frac{1}{137.0359900996} \tag{2.1}$$

in [18], which computes the fine-structure constant at zero energy. This shows the signature of the control number 117 in α.

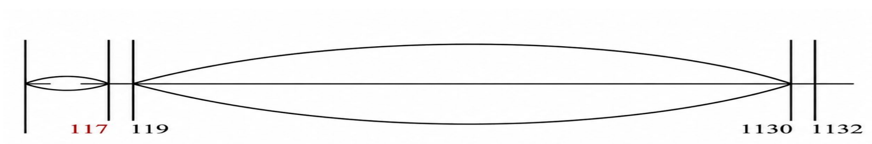

Figure 1. Golden section control numbers.

A vital aspect of modern QED is that physical constants can exhibit scale-dependent behavior. As energy scales increase, QED predicts the running of α toward higher values. Just as low energy interactions have been framed by the baseline integer 117, Mamombe (2024) [16] noticed that α at high energies can also be derived from the control numbers shown in Figure 1, leading to the observation that "*at this point, the notion of coincidence disappears. It becomes obvious the control numbers in* Figure 1 *relate to the fine-structure constant.*"

Equation (2.1) leads to the identification of the bifurcation region (117 - 119) in Figure 1 as the low-energy bracket. At Z boson mass scale, we have $\alpha(M_z)$ computed in [16] as

$$100^2\left(\frac{1}{1130}\right)^2 = 0.007831466833737 = \frac{1}{127.69} \tag{2.2}$$

This identifies the bifurcation region (1130 - 1132) as the high energy bracket. The emergence of these specific integer pairings (117 - 119 as the low energy bracket and 1130 - 1132 as the high energy bracket) carries several conceptual implications for theoretical physics and number theory. Rather than treating the variation of α purely as an artifact of quantum field fluctuations, these results imply that coupling constants may trace back to deep geometric and Platonic properties of golden section quasigeometric sequences. The numerical relationships investigated here are neither based on assigning significance to preselected integers nor on seeking numerical coincidences with known physical constants. Control numbers strictly emerge from the behaviour of quasigeometric sequences. Their relevance is therefore determined by the mathematical structure of the sequences rather than by an a priori interpretation of the numbers themselves. The subsequent computation of physical constants constitutes an application rather than a procedure for selecting the control numbers. In this sense, this approach differs fundamentally from numerological methods, in which numerical patterns are generally interpreted without an independently specified mathematical mechanism. Here, the physical constants are used as an external test of whether those independently obtained control numbers recur in nature.

Having established the crucial role played by control numbers in the fine-structure constant computations, an important aspect of mapping these numbers is their extension beyond Abelian QED into non-Abelian QCD. Examining the strong coupling constant, we observe that the world average value as of 2026, evaluated at the mass of the Z boson, $\alpha_s(M_z)$, given in [14] as

$$\alpha_s(M_z) \approx 0.1180(9) \tag{2.3}$$

numerically lies within the first bifurcation region in Figure 1. This is illustrated in Figure 2.

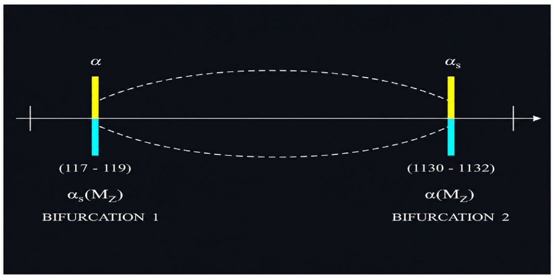

Figure 2. Control numbers and coupling constants.

Within this framework, the numerical string format of 0.1180(9) exhibits a direct structural echo of the lower control bracket (117 - 119). Notice that

$$0.1180(9)\times 10^{3}=118.0\pm 0.9 \tag{2.4}$$

Therefore

$$\frac{117.1}{10^{3}}\le \alpha_{s}\left(M_{z}\right)\le \frac{118.9}{10^{3}} \tag{2.5}$$

3. Discussion

It is important to distinguish this structural correspondence from a dynamical derivation of the QCD coupling. The present analysis does not propose a QCD mechanism that generates $\alpha_s\left(M_z\right)$ from control numbers. Rather, the control numbers arise independently from the behaviour of golden section quasigeometric sequences, and their recurrence in independently determined coupling parameters is examined as a mathematical signature. Thus, the result should be interpreted as evidence for a possible underlying numerical-geometric relationship, rather than as a replacement for the renormalization-group description of QCD. Establishing a physical mechanism connecting the two frameworks remains an open question for future investigation. In other words, an independently generated mathematical structure repeatedly appears in numerical representations associated with fundamental coupling constants, and this recurrence merits investigation as a possible number-theoretic/geometric relationship. The appearance of these control numbers therefore extends the observed numerical correspondence beyond electromagnetism into the strong interaction sector. The extension from the fine-structure constant to $\alpha_s\left(M_z\right)$ provides an additional test of whether the same control number structure occurs across different interaction sectors.

4. Conclusions

We have found that the utility of golden section control numbers extends beyond Abelian QED to the strong coupling constant in non-Abelian QCD. The detection of control number signatures in α, $\alpha\left(M_z\right)$, and $\alpha_s\left(M_z\right)$ indicates that these control numbers may encode a recurring numerical-geometric structure associated with fundamental physical constants, suggesting that while standard paradigms treat coupling constants as empirically derived quantities governed by quantum field renormalization, they may relate to the geometric constraints of Platonic number systems.

Furthermore, there exists a computational point of intersection between α and $\alpha_s\left(M_z\right)$ through the control number structure. This profound numerical and geometric convergence suggests that QCD and QED parameters may share a number-theoretic ancestry. This observation may prove valuable for ongoing and future research. These results suggest that quasigeometric sequences may provide a useful mathematical framework for modeling physical phase transitions.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

References

[1] Gross, D.J. and Wilczek, F. (1973) Ultraviolet Behavior of Non-Abelian Gauge Theories. *Physical Review Letters*, **30**, 1343-1346. https://doi.org/10.1103/physrevlett.30.1343

[2] Politzer, H.D. (1973) Reliable Perturbative Results for Strong Interactions? *Physical Review Letters*, **30**, 1346-1349. https://doi.org/10.1103/physrevlett.30.1346

[3] The ATLAS Collaboration (2023) A Precise Determination of the Strong-Coupling Constant from the Recoil of Z Bosons with the ATLAS Experiment at √s = 8 TeV. https://arxiv.org/abs/2309.12986

[4] d'Enterria, D., *et al.* (2024) The Strong Coupling Constant: State of the Art and the Decade Ahead. *Journal of Physics G: Nuclear and Particle Physics*, **51**, Article ID: 090501.

[5] Ablat, A., *et al.* (2026) Strong Coupling Constant Determination from the New CTEQ-TEA Global QCD Analysis. https://arxiv.org/abs/2512.23792

[6] Bronnikov, K.A., Ivashchuk, V.D. and Khruschov, V.V. (2025) The Fine-Structure Constant: A Review of Measurement Results and Possible Space-Time Variations. *Measurement Techniques*, **68**, 125-134. https://doi.org/10.1007/s11018-025-02433-2

[7] Auci, M. (2025) Estimation of the Coupling Constants for the Strong Interaction in the Framework of the Electromagnetic Bridge Theory. *Applied Physics Research*, **17**, 66-79. https://doi.org/10.5539/apr.v17n2p66

[8] Ahmadova, F., Britzger, D., Chen, X., Gäßler, J., Gehrmann-De Ridder, A., Gehrmann, T., *et al.* (2025) Precise Determination of the Strong Coupling Constant from Dijet Cross Sections up to the Multi-TeV Range. *Physical Review Letters*, **135**, Article ID: 031903. https://doi.org/10.1103/knrv-2r3t

[9] Del Debbio, L. and Ramos, A. (2021) Lattice Determinations of the Strong Coupling. *Physics Reports*, **920**, 1-71. https://doi.org/10.1016/j.physrep.2021.03.005

[10] Alexander, G. and Blok, B. (2019) The Bose-Einstein Correlations and the Strong Coupling Constant at Low Energies. *Physics*, **1**, 59-66. https://doi.org/10.3390/physics1010006

[11] Camarda, S., Ferrera, G. and Schott, M. (2024) Determination of the Strong-Coupling Constant from the Z-Boson Transverse-Momentum Distribution. *The European Physical Journal C*, **84**, Article No. 39. https://doi.org/10.1140/epjc/s10052-023-12373-2

[12] Pellis, S. (2023) Unity Formulas for the Coupling Constants and the Dimensionless Physical Constants. *Journal of High Energy Physics, Gravitation and Cosmology*, **9**, 245-294. https://doi.org/10.4236/jhepgc.2023.91021

[13] Mohr, P.J., Newell, D.B., Taylor, B.N. and Tiesinga, E. (2025) CODATA Recommended Values of the Fundamental Physical Constants: 2022. *Reviews of Modern Physics*, **97**, Article ID: 025002. https://doi.org/10.1103/revmodphys.97.025002

[14] Takahashi, F., *et al.* (2026) Physical Constants. (Particle Data Group). *International Journal of Modern Physics A*, **41**, Article ID: 2630011.

[15] Gross, D.J. (2004) Asymptotic Freedom and QCD—A Historical Perspective. *Nuclear Physics B—Proceedings Supplements*, **135**, 193-211. https://doi.org/10.1016/j.nuclphysbps.2004.09.049

[16] Mamombe, L. (2024) Fine-Structure Constant at Low and High Energies. *Journal of Applied Mathematics and Physics*, **12**, 4098-4103. https://doi.org/10.4236/jamp.2024.1212250

[17] Marples, C.R. and Williams, P.M. (2022) The Golden Ratio in Nature: A Tour across Length Scales. *Symmetry*, **14**, Article No. 2059. https://doi.org/10.3390/sym14102059

[18] Mamombe, L. (2017) Proportiones Perfectus Law and the Physics of the Golden Section. *Asian Research Journal of Mathematics*, **7**, 1-41. https://doi.org/10.9734/arjom/2017/36860