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UNIFICATION OF EXCEPTIONAL HOLONOMY AND CALIBRATED GEOMETRY: STRUCTURAL RESULTS AND GEOMETRIC IMPLICATIONS

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ABSTRACT

This paper establishes a comprehensive framework unifying exceptional holonomy groups with calibrated geometry through novel structural theorems and computational methods. We demonstrate that manifolds admitting special holonomy groups G_2 and Spin(7) possess intrinsic calibration forms whose geometric properties determine topological invariants. Our investigation reveals previously unexplored connections between Cayley calibrations, associative submanifolds, and their moduli spaces. We introduce five computational algorithms for identifying calibrated submanifolds and present ten arithmetic results quantifying geometric structures. The proposed unified framework extends classical Riemannian holonomy theory while providing explicit construction methods for exceptional geometric structures. Our experimental analysis validates theoretical predictions through explicit calculations on toric varieties and Joyce manifolds. These findings have significant implications for string theory compactifications and geometric analysis on singular spaces.

KEYWORDS: *Exceptional Holonomy, Calibrated Geometry, G_2 Manifolds, Spin(7) Structures, Associative Submanifolds, Cayley Submanifolds*

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