Geometric Calculus in Gravity Theory

A major impetus to develop Geometric Calculus has been improvement of General Relativity. The ultimate integration of gravity theory and quantum mechanics should be facilitated by the development of a suitable common language. Work toward that goal began with the DH doctoral dissertation (1963) and continued through his 1963-64 postdoctoral fellowship with John Wheeler at Princeton. The first result was published in Space-Time Algebra (1966). The next result was a product of the extensive development of new mathematical tools for differential geometry in CA to GA. The first two papers listed below apply GC to General Relativity; they were adapted fom a chapter written for CA to GC in 1976 but dropped when applications were excluded from the book. The third paper was written in 1993-94 during a DH sabbatical at Canvendish Laboratory. It was intended for publication in the *Journal of Mathematical Physics*, but the editor rejected it as unsuitable without consulting reviewers. Publication in another journal was not pursued, as that was likely to require extensive rewriting. Anyway, the present Web publication puts it in a more helpful context for readers. Many papers on the new Gauge Theory of Gravity using Geometric Calculus are posted at the Cavendish Web site.

Curvature Calculations with Spacetime Algebra

Abstract: A new method for calculating the curvature tensor is developed and applied to the Schwarzschild case. The method employs Clifford algebra and has definite advantages over conventional methods using differential forms or tensor analysis.

D. Hestenes, *Int. J. Theo. Phys.*, **25**, 1986, 581-588.

Spinor Approach to Gravitational Motion and Precession

Abstract: The translational and rotational equations of motion for a small rigid body in a gravitational field are combined in a single spinor equation. Besides its computational advantages, this unifies the description of gravitational interaction in classical and quantum theory. Explicit expressions for gravitational precession rates are derived.

D. Hestenes, *Int. J. Theo. Phys.*, **25**, No. 6, December 1986, 589-598.

Spacetime Calculus for Gravitation Theory

Abstract: A new *gauge theory of gravitation* on flat spacetime has been formulated in the language of Geometric Calculus. This paper provides a systematic account of the mathematical formalism to facilitate applications and extensions of the theory. It includes formulations of differential geometry, Lie derivatives and integrability theorems which are coordinate-free and gauge-covariant. Emphasis is on use of the language to express physical and geometrical concepts.

Gauge Theory Gravity with Geometric Calculus

Abstract: A new *gauge theory of gravity* on flat spacetime has recently been developed by Lasenby, Doran, and Gull. Einstein's principles of equivalence and general relativity are replaced by gauge

principles asserting, respectively, local rotation and global displacement gauge invariance. A new unitary formulation of Einstein's tensor leads to resolution of long-standing problems with energymomentum conservation in general relativity. *Geometric calculus* provides many simplifications and fresh insights in theoretical formulation and physical applications of the theory.

D. Hestenes, *Foundations of Physics*, 35(6):903-970 (2005).

Spacetime Geometry with Geometric Calculus

Abstract: *Geometric Calculus* is developed for curved-space treatments of General Relativity and comparison with the flat-space gauge theory approach by Lasenby, Doran and Gull. Einstein's Principle of Equivalence is generalized to a gauge principle that provides the foundation for a new formulation of General Relativity as a Gauge Theory of Gravity on a curved spacetime manifold. Geometric Calculus provides mathematical tools that streamline the formulation and simplify calculations. The formalism automatically includes spinors so the Dirac equation is incorporated in a geometrically natural way.

D. Hestenes, To be published in the *Preceedings of the Seventh International Conference on Clifford Algebra*

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