Space, Time and Matter: The Foundations of Geometrodynamics. Introductory Remarks

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SPACE, TIME AND MATTER: THE FOUNDATIONS OF GEOMETRODYNAMICS

Introductory Remarks

At the 1960 International Philosophy of Science Congress, J. A. Wheeler gave a synoptic paper entitled 'Curved Empty Space-Time as the Building Material of the Physical World'. In this paper, Wheeler (1962a) posed the following question (p. 361):

> Is space-time only an arena within which fields and particles move about as 'physical' and 'foreign' entities? Or is the four-dimensional continuum all there is? Is curved empty geometry a kind of magic building material out of which everything in the physical world is made: (1) slow curvature in one region of space describes a gravitational field; (2) a rippled geometry with a different type of curvature somewhere else describes an electromagnetic field; (3) a knotted-up region of high curvature describes a concentration of charge and mass-energy that moves like a particle? Are fields and particles foreign entities immersed *in* geometry, or are they nothing *but* geometry?
>
> It would be difficult to name any issue more central to the plan of physics than this: whether space-time is only an arena, or whether it is everything.... In 1870 Clifford put the issue before the Cambridge Philosophical Society in a more explicit form than anyone ever had before – or anyone was to do for many decades: "I hold in fact (1) that small portions of space *are* in fact of a nature analogous to little hills on a surface which is on the average flat; namely, that the ordinary laws of geometry are not valid in them; (2) that this property of being curved or distorted is continually being passed on from one portion of space to another after the manner of a wave; (3) that this variation of the curvature of space is what really happens in that phenomenon which we call the motion of *matter*, whether ponderable or ethereal; (4) that in the physical world nothing else takes place but this variation, subject (possibly) to the law of continuity."

Wheeler epitomized his own attitude toward the monistic ontology envisioned by W. K. Clifford by declaring (Wheeler, 1962b, p. 225):

> There is nothing in the world except empty curved space. Matter, charge, electromagnetism, and other fields are only manifestations of the bending of space. *Physics is geometry.*

And Wheeler (1962a, pp. 365–368) points out that in 1956, Charles Misner – one of our symposiasts – rediscovered a forgotten result due to Rainich as follows: electromagnetism can be *geometrized along with* gravitation in a unified way (via one set of purely geometrical 4th order equations) within the framework of Einstein's 1916 theory. In this way, Misner showed, as Wheeler puts it, how we can have 'electromagnetism without electromagnetism' (Wheeler, 1962a, p. 368) by building the electromagnetic field *out* of space-time geometry, as it were. By the same

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token, Misner showed how Einstein's theory can evade Pauli's jocular complaint that unified theory had disobeyed the injunction: "Let no man join together what God has put asunder."

Six years later, Wheeler (1968) published a book in German entitled *Einsteins Vision* whose subtitle is 'What is the Current Status of Einstein's Vision to Conceive of Everything as Geometry?'. Wheeler tells us that Einstein was animated by the hope of implementing Clifford's conception of the universe as one of pure geometry (1962a, p. 361):

> The vision of Clifford and Einstein can be summarized in a single phrase, 'a geometrodynamical universe': a world whose properties are described by geometry, and a geometry whose curvature changes with time – a *dynamical* geometry.

For nineteen years, Wheeler and his co-workers developed some of the detailed physics of Clifford's 1870 ontology of curved empty space-time as an outgrowth of general relativity under the name of 'geometrodynamics' ('GMD'). But in a lecture given at a conference held within a few weeks after the present Symposium,[1] Wheeler disavowed his erstwhile long quest for a reduction of all physics to space-time geometry. In a brief notice of that Conference (*Nature* **240** (1972)),[2] the pertinent part of this lecture was summarized as follows: "He [Wheeler] also developed the theme that the structure of space-time could only be understood in terms of the structure of elementary particles rather than the converse statement which he has advocated for many years."

Some of the accomplishments, prospects and problems of GMD are canvassed in the papers by Misner and Stachel below.

Another GMD Symposium was held at the December 1972 Boston Meeting of the American Philosophical Association. The contributions by the principal speakers at the latter Symposium are available in Earman (1972), Graves (1972) and Stein (1972).

The remarks which I made as session chairman of the two Geometrodynamics Symposia held at the October 1972 PSA Congress and at the December 1972 APA Meeting have been expanded into a monograph-length chapter 'General Relativity, Geometrodynamics and Ontology' (Grünbaum, 1973b, Ch. 22). Some excerpts from this chapter, which has been significantly influenced by John Stachel, appear in Grünbaum (1973a) while other extracts are published in Grünbaum (1973c).

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NOTES

* Chairman of the Symposium.

[1] Conference on Gravitation and Quantization, held in Oct. and Nov., 1972 at the Boston University Institute of Relativity Studies, directed by John Stachel. I am grateful to Professor Stachel for having given me the opportunity to attend this conference.

[2] Wheeler's own published repudiation of GMD has since become available in C. W. Misner, K. S. Thorne, and Wheeler, *Gravitation*, Freeman, San Francisco, 1973, §44.4, 1203–1208.

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