14. Kinematic Connections and Their Application to Physics.

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Recently a new physical theory has been developed by O. Veblen,[1] J. A. Schouten[2] and others in which the principal point is founded on a projective connection. In the present paper we shall develop some connections in the manifold admitting the kinematic transformations, and shall give a unification of the gravitational field not only with the electromagnetic, but also with Dirac's theory of material waves.

Let the equations

(1. a) $$\bar{x}^i=\bar{x}^i(x^0, x^1, x^2, x^3, x^4), \qquad i=1, 2, 3, 4,$$

be the transformations of the coördinates in X_4, where x^0 is a parameter, and we shall define the transformation of the parameter by

(1. b) $$\bar{x}^0=x^0.$$

These transformations (1. a) and (1. b) are collectively called a *kinematic transformation* in the manifold X_4.

The kinematic transformation (1. a), (1. b) can be regarded as follows. An ordered set of the five independent real variables x^ν ($\nu=0, 1, 2, 3, 4$),[3] of which at least one is not zero may be considered as a coördinate system of a 5-dimensional manifold X_5 except the original point. Two points x^ν and y^ν are called coincident if a factor exists, so that $y^\nu=\sigma x^\nu$. Each totality of all points coincident with any point is called a spot. The totality of all ∞^4 spots is called the 4-dimensional projective manifold P_4. The set of all points of the P_4, with the exception of those on a single 3-dimensional projective manifold P_3 contained in the P_4, is called the affine manifold A_4. By choosing the P_3 as the hyperplane at infinity, the equation of the P_3 may be written in the form $x^0=0$. Thus (1. a) and (1. b) are transformations of coördinates in A_4, and by them P_3 is transformed into itself.

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1) O. Veblen: Projektive Relativitätstheorie. Julius Springer, 1933.

2) J. A. Schouten und D. van Dantzig: Generelle Feldtheorie, Zeit. für Physik, **78** (1932), 639–667.

3) Let us make the convention that Greek indices run over the range 0, 1, 2, 3, 4, whereas the Latin indices take on the values 1, 2, 3, 4 only.