By (xi), the , a denotes partial differentiation with respect to x^a as well as ξ^a for those functions which, through the A-cylindrical condition, are independent of ξ^5. The array:

$$f_{ab} = \varphi_{ab}/\sqrt{\gamma_{55}}$$

therefore is derivable from a four-vector potential in the same way as the electromagnetic field tensor in ordinary relativity, and so satisfies part of Maxwell's equations.

Using the above formulæ, the components of the five-dimensional Christoffel symbols can be evaluated in terms of those in the four-dimensional space. It is found that:

$$\left\{ {s \atop \alpha\beta} \right\}_{(5)} = \gamma^a_\alpha \gamma^b_\beta \left\{ {s \atop ab} \right\}_{(4)} + \tfrac{1}{2} g^{sr} \gamma^\rho_r \left(A_\alpha A_{\rho\beta} + A_\beta A_{\rho\alpha} \right)$$

$$A_\mu \left\{ {\mu \atop \alpha\beta} \right\}_{(5)} = \tfrac{1}{2}(A^\rho A_\alpha A_{\rho,\beta} + A^\rho A_\beta A_{\rho,\alpha} + A_{\alpha,\beta} + A_{\beta,\alpha})$$

$$\left\{ {\sigma \atop \alpha\sigma} \right\}_{(5)} = \gamma^a_\alpha \left\{ {s \atop as} \right\}_{(4)} + A^\sigma A_{\sigma,\alpha}$$

With these, operating on the geodesic equations:

$$\frac{\delta}{\delta\sigma}\left(\frac{d\xi^\mu}{d\sigma}\right) \equiv \frac{d^2\xi^\mu}{d\sigma^2} + \left\{ {\mu \atop \alpha\beta} \right\}_{(5)} \frac{d\xi^\alpha}{d\sigma} \frac{d\xi^\beta}{d\sigma} = 0$$

with γ^a_μ gives (1), and operating with A_μ gives (2). In (1) and (2):

$$m_0 = \alpha \frac{ds}{d\sigma}, \alpha \text{ constant,}$$

and:

$$e = m_0 c^2 \sqrt{\gamma_{55}} A_\mu \frac{d\xi^\mu}{ds}$$

Operating on the equations of conservation:

$$J^{\mu\nu}{}_{;\nu} \equiv \left(\rho \frac{d\xi^\mu}{d\sigma} \frac{d\xi^\nu}{d\sigma} + \tilde{\omega}\gamma^{\mu\nu} \right)_{;\nu} = 0$$

with γ^a_μ gives (3), and operating with A_μ gives (4). In (3) and (4):

$$r = \sqrt{\gamma_{55}}\, \rho \left(\frac{ds}{d\sigma}\right)^2$$

$$p = \sqrt{\gamma_{55}}\, \tilde{\omega}$$

$$\varepsilon_1 = -r \sqrt{\gamma_{55}} A_\mu \frac{d\xi^\mu}{ds}$$

N. W. Taylor

Department of Mathematics,
University of New England,
Armidale.

[1] Bailey, V. A., *Nature*, **186**, 508 (1960).
[2] Lichnerowicz, A., *Théories relativistes de la gravitation et de l'électromagnétisme*, livre 2 (Masson et Cie, Paris, 1955).
[3] Bergmann, P. G., *Introduction to the Theory of Relativity*, Chap. xvii (Prentice-Hall, New York, 1942).
[4] Bailey, V. A., *Nature*, **189**, 44 (1961).
[5] Bailey, V. A., *Nature*, **184**, 537 (1959).
[6] Hoyle, F., *Mon. Not. Roy. Astro. Soc.*, **108**, 372 (1948).

The suggestion that a five-dimensional model (U_5) of the Universe may be useful in cosmology[1] led quite naturally to the view that the laws of conservation of momentum, energy and electric charge are strictly true in such a universe U_5 and only approximately true in our space–time universe U_4.

This view led later to the conclusion that stars like the Sun carry large negative charges[2] and in this way provided a unified theory of several different astrophysical phenomena and also led to successful predictions concerning the interplanetary magnetic field measurements of the solar satellite *Pioneer V*[3].

These facts show that Dr. Taylor's quantitative discussion of five-dimensional cosmology is of distinct importance, for it not only confirms the view stated above but also is remarkable for its derivation of the empirically correct sign of the Sun's net charge[3].

It is to be hoped that in due course the correct field equations will be derived from the five-dimensional model. It is true that Kaluza has given an associated variational procedure[4] by means of which he derived Maxwell's electromagnetic field equations and Einstein's gravitational field equations; but this particular procedure probably yields only a first approximation for weak fields, for Einstein has pointed out that the existence of stable charged particles like electrons requires that the correct electromagnetic field equations be non-linear in the field variables. Guides to finding a correct procedure may perhaps exist in current non-linear field equations such as those due to Born, Infeld and Dirac[5].

It may be noted that Dr. Taylor's conclusion that the charge density ε varies inversely as the quantity $1 + p_0/r_0c^2$ leads also to the conclusion that the rate of apparent creation of net charge in interstellar space is small compared with the rate near and inside stars. This and the negative sign for the charge are conclusions which disagree with the hypotheses of Lyttleton and Bondi[6].

Lastly, it may be pointed out that additional direct observations of interplanetary magnetic fields, made by means of a pair of differently moving space vehicles in a relatively small region, would offer additional evidence on the hypothesis that the Sun carries a large negative charge and so perhaps offer evidence concerning the five-dimensional model of the Universe.

V. A. Bailey

School of Physics,
University of Sydney.

[1] Bailey, V. A., *Nature*, **184**, 537 (1959).
[2] Bailey, V. A., *Nature*, **186**, 508 (1960).
[3] Bailey, V. A., *Nature*, **189**, 44 (1961).
[4] Bergmann, P. G., *Introduction to the Theory of Relativity*, 267 (Prentice-Hall, New York, 1953).
[5] Dirac, P. A. M., *Proc. Roy. Soc.*, A, **257**, 32 (1960).
[6] Lyttleton, R. A., and Bondi, H., *Proc. Roy. Soc.*, A, **252**, 313 (1959).

GROWTH OF ALLOPREGNANE SINGLE CRYSTALS

By Dr. DORITA A. NORTON and LORENZO COSTA

Department of Biophysics, Roswell Park Memorial Institute, Buffalo, New York

PART of our programme of determining the molecular structures of steroids by X-ray crystallographic methods is the growth of good single crystals. For our purposes a good single crystal is one having the following characteristics: (1) a unique lattice orientation; (2) absence of strain; (3) absence of impurities; (4) a reasonably small number of vacancies and dislocations; (5) an ideally imperfect nature; (6) a diameter within the 0·2–1·0 mm. range; (7) well-defined external faces.