the motion, which is also taken to approximate to the Newtonian case as the density tends to zero.

I am, however, unable to say what the movement would be in case the masses at the centre occasion a 'horizon' of the de Sitter type. If electromagnetic components are present among the forces, the paths may remain bounded instead of receding to infinity, as such forces have a 'non-energic' component.

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July 28.

It is very satisfactory to find that the explanation I have given of the phenomena of the expanding universe can be freed from some of the restrictions which were introduced. The essential point in the explanation, as I pointed out, is that we have to do with an unenclosed system; if the system contains some high velocity particles, it will necessarily expand. Mr. Kosambi points out that the expansion and recession to infinity may also occur under more general conditions. But Mr. Kosambi is scarcely correct in saying that in my explanation "the material particles that form the universe are taken initially to have been enclosed in some finite space". I used the finite occupied sphere surrounded by infinite empty space as the most striking illustration of the principle (it was the way the explanation originally occurred to me), but as I explicitly pointed out, any 'initial' density distribution with a concentration towards one region will give rise to the expansion phenomenon; and for the particular relativistic world-structure which I outlined the initial density-distribution extends throughout *infinite* Euclidean space.

The statistical mechanics of an unenclosed system ("a gas-container with the lid off") requires detailed consideration, for it is significantly different from the statistical mechanics of an enclosed system. In particular, the entropy principle no longer holds in its usual form. Maxwell speculated on the consequences of the existence of a velocity sorter, a 'sorting demon'. An unenclosed universe is itself its own sorting demon, and the pessimistic conclusions of Jeans and others as to an inevitable heat-death for the universe must be viewed with doubt.

If point-events are ultimately found to be confined to a finite 3-spread, mathematicians will be entitled to describe the relationships of these point-events by means of a Riemannian metric; but observation has already compelled the introduction of an *expanding* 3-spread if this line of thought is to be retained, with its manifest difficulties, including the re-introduction of an absolute time. In the meantime I prefer to describe these relationships by means of the infinite Euclidean space of any one observer, together with his own particular time. To speak of 'space' itself as curved or finite is of course meaningless, for 'space' is no objective entity; space and time are merely the observer's dissection of that reality which is the change in the observed mutual relationships of observed material particles—what Bergson called "le devenir", or the process of becoming. To describe this reality we may adopt any conceptual space we choose, provided it has the correct number of dimensions.[1] The space of my first paragraph above is the conceptual Euclidean space of any one observer.

The most general scheme of matter and motion for the ground-plan of the universe, that is, the most general description of the above reality, consistent with the observed facts on which the special theory of relativity was based, appears to be given by the distribution-law (for any one observer)

$$F\left(\frac{Z^2}{XY}\right)\frac{dxdydzdudvdw}{c^6 Y^{\frac{3}{2}} X^{\frac{3}{2}}},$$

where X is the invariant

$$t^2 - \frac{x^2+y^2+z^2}{c^2},$$

and Y and Z are respectively the covariants

$$1 - \frac{u^2+v^2+w^2}{c^2},$$

$$t - \frac{ux+vy+wz}{c^2},$$

x, y, z, t being reckoned from the natural space-time origin of the observer. The distribution I gave in my synopsis (Nature, July 2, 1932) was the particular case of rectilinear motions, for which

$$F \equiv \frac{\text{constant}}{[(Z^2/XY)-1]^{3/2}}.$$

In general to any function F corresponds a definite acceleration of each material particle and curvature of world lines. The condition that the accelerations near ourselves, for small velocities, coincide with those predicted by the Newtonian law leads to the relation

$$\frac{4}{3}\pi G\rho = \frac{D}{t^2}$$

where G is the gravitational constant, D is a constant less than unity, ρ is the present mean density of the smoothed-out universe near the observer, and t is the observer's reckoning of the time that has elapsed from the space-time origin; t is to be calculated from $V \sim r/t$ where V is the mean observed recession-velocity at observed distance r. This evaluates ρ as not greater than 10^{-27} gram. cm.$^{-3}$.

The possibility of the construction of a universe which appears to *every* observer to be completely centred round himself, wherever he be, and which at the same time thins away at great distances from himself, removes those difficulties which originally led Einstein to adopt a curved finite continuum for the description of the universe.[2] And the fact that we now observe recession-velocities comparable with that of light destroys any justification for the existence of a 'cosmic time', for there is no longer a co-ordinate system in which the observed velocities of celestial objects are all small compared with that of light.[3] In my opinion, these considerations remove many of the traditional philosophical difficulties concerning time and space as a means of description of matter and motion.

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Aug. 19.

[1] Cf. Larmor, "Questions in Physical Interdetermination", *C.R. du Congrès Internat. des Mathématiciens*, 1920, p. 13.
[2] See Einstein, *Sitz. Preuss. Akad. Wiss.* (1917), 150, and "Relativity", English Trans. 4th edition, 1921, Part III.
[3] Cf. Einstein, loc. cit., Chap. 32, p. 113.

Inheritance of Acquired Characters

In 1815, Lamarck propounded the hypothesis that all which has been acquired, laid down or changed in the organisation of individuals in the course of their life is conserved by generation and transmitted to the new individuals which proceed from those which have undergone those changes.

This doctrine is at present somewhat discredited and Prof. T. H. Morgan recently asserted that the stories in the folk-lore of primitive peoples which take for granted that acquired characters are inherited appeal to our sense of humour, and would long ago have been forgotten or disregarded by men of science were it not that in every generation new illustrations are continually brought forward.

In adducing such illustrations, the difficulty is to prove that the characters in question are outside the