BULL. AUSTRAL. MATH. SOC. 85A40, 83F05
VOL. 11 (1974), 471-472.

On newtonian and relativistic cosmology

A.B. Evans

After a review of the standard methods of newtonian cosmology, there follows a reappraisal of the cosmological principle in newtonian universes. This is motivated by the need for generality when shear and rotation are allowed, and a formulation is developed on the same group-of-motions basis as is commonly used in relativistic cosmology. The usual newtonian universes are derived, but in addition there is a new type in which the velocity of matter is no longer a linear function of the spatial coordinates [3], [5].

An approach to newtonian cosmology that was initiated by Narlikar [6] is pursued in some depth [1], [2]. Narlikar's analysis of universes with isotropic gravitational potential is shown to be faulty, but his assertion that all such models have a singularity turns out to be correct. Attention is concentrated on cylindrically symmetric models, which have the same density evolution as a much broader class. Their equations of motion are reducible to quadratures, most of which can be evaluated exactly, and this permits a detailed analysis of their singularities. These singularities are always of pancake form when there is rotation. Plausible rotating cylindrical models for the actual universe are discussed.

However, the gravitational potential of an infinite newtonian universe is necessarily somewhat arbitrary, and the assumption that it is isotropic when the motion is not conflicts with general relativity. This motivates the derivation of a 'relativistic' newtonian potential, so that the dynamics of relativistic dust universes can be expressed in a comparatively simple classical form [4].

The kinematic framework is first set up, by correlating the local

Received 22 August 1974. Thesis submitted to the University of Otago, January 1974. Degree approved, July 1974. Supervisor: Professor W. Davidson.

https://doi.org/10.1017/S0004972700044129 Published online by Cambridge University Press

behaviour of a general comoving metric with the motion of a newtonian universe of the usual (linear-velocity) sort. The field equations then show that the relativistic potential is affected not only by matter, but also by motion (via the expansion and shear, though not the spin), and by anisotropy in the spatial curvature. The effect of this last factor is indeterminate unless the metric is already known, but the quasi-newtonian equations of motion are nevertheless of some heuristic value. They can in particular be used to classify behaviour at singularities and during indefinite expansion, and this is illustrated by a number of examples from among the homogeneous relativistic world models, including some with rotation. Curvature anisotropy is especially important, playing a central role both in expansion and in some singularities of a hitherto unreported type.

References

[1] W. Davidson and A.B. Evans, "A fresh look at the cosmological singularity", *Nature (Phys. Sci.)* 232 (1971), 29-31.

[2] W. Davidson and A.B. Evans, "Newtonian universes expanding or contracting with shear and rotation", *Internat. J. Theoret. Phys.* 7 (1973), 353-378.

[3] A.B. Evans, "Newtonian universes with non-linear velocity", *Phys. Lett.* 44A (1973), 211-212.

[4] A.B. Evans, "A newtonian view of relativistic cosmology", *Nature* (to appear).

[5] A.B. Evans and W. Davidson, "The cosmological principle in newtonian universes", *Mon. Not. Roy. Astron. Soc.* 165 (1973), 323-336.

[6] J.V. Narlikar, "Newtonian universes with shear and rotation", *Mon. Not. Roy. Astron. Soc.* 126 (1963), 203-208.