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Editor's Note:
Effect of inhomogeneity on cosmological models

by Richard C. Tolman, *Proceedings of the National Academy of Sciences of the USA* **20 (1934), 169–176**

In the Einstein static Universe the gravitational self-attraction of homogeneously distributed matter and the cosmological repulsion implied by the cosmological constant balance each other. Eddington [1] showed in 1930 that this balance is unstable: any departure from it will cause the Universe to either expand or collapse away from the initial state. The perturbed solutions are the Friedmann models. Tolman, in the paper reprinted in this issue, showed that there exists one more instability: both the Einstein model and the Friedmann model with positive spatial curvature are unstable against perturbations of the spatially homogeneous density distributions (the initial velocity distribution remaining unchanged). The perturbations are provided by the solution of Lemaître [2] presented as the preceding part of this series [3]. The instability is triggered by local condensations as well as by local rarefactions in the density distribution; the latter would be today called voids. Tolman was well aware of the implications of this result for relativistic cosmology; the paper contains an explicit warning against light-hearted use of the Friedmann models for describing the Universe over large regions of space and long periods of time. One is tempted to think that, by saying so, Tolman demonstrated a deeper understanding of cosmology than many modern astrophysicists do. Had he only been taken seriously...

The modern reader can recognize a modest predecessor of the singularity theorems in this paper [the paragraphs after eqs. (25) and (35)].

Tolman's paper is often cited today as the source for the solution of Einstein's equations discussed in it, and the solution is usually called the "Tolman model". However, there is evidence that this paper is almost

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never being read. Proof: Tolman himself made it clear that the solution is Lemaître's. No-one who has read this would ever call this solution a "Tolman model". As mentioned in the editorial note to Ref. 3, we propose to call this model "Lemaître–Tolman".

Readers interested in the subject (especially those who are going to publish papers on it) are advised to study also the paper by Bondi [4]. It is a brilliant and enlightening discussion of geometrical and physical properties of the Lemaître–Tolman model. The paper is often quoted, but again rather rarely read. Several ideas and notions introduced in it have been reinvented (and developed further) in the 1970s.

In his footnote 4, Tolman most probably refers to the paper listed as Ref. 5 below, in which H. Dingle was well on the way to deriving a class of other generalizations of the Friedmann models. This class was eventually derived by Kustaanheimo and Qvist [6]; Ref. 6 will be reprinted as No. 6 in our series. Dingle has narrowly missed success because he used an inconvenient parametrization, and resorted to perturbative calculations instead.

— *Andrzej Krasiński, Associate Editor*

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5. Dingle, H. (1933). *Mon. Not. Roy. Astr. Soc.* 94, 134.
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Tolman: a brief biography

Richard Chace Tolman was born in West Newton, Mass., USA, on 4 March 1881. He received his B.S. degree in chemical engineering in 1903 from the Massachusetts Institute of Technology. After one year (1904) in Germany he worked at M.I.T. in a physical chemistry laboratory, and received his Ph.D. there in 1910. In the following years he was employed at the Universities of Michigan, Cincinnati, California at Berkeley and Illinois. During World War I he served in the Chemical Warfare Service.

After the war he helped to found the Fixed Nitrogen Research Laboratory in 1919, and became its associate director (1919–20) and director (1920–22).

In 1922 he joined the faculty of the California Institute of Technology, where he was professor of physical chemistry and mathematical physics, dean of the graduate school and a member of the executive council. During World War II, among other positions, he served as vice-chairman of the National Defense Research Committee and adviser on the Manhattan Project, and later as adviser on the UN Atomic Energy Commission.

The main subjects of Tolman's work were statistical mechanics, relativistic thermodynamics and cosmology. His most lasting contributions to science are his books: *The Theory of the Relativity of Motion* (with G. N. Lewis, 1917, said to be the first American exposition of special relativity), *Relativity, Thermodynamics and Cosmology* (1934, still instructive reading, especially on thermodynamics) and *Principles of Statistical Mechanics* (1938, still a classic).

R. C. Tolman died on 5 September 1948 in Pasadena, California.

— *Andrzej Krasiński, Associate Editor*
based on Ref. 1

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The editor is grateful to J. Eisenstaedt for directing him to Ref. 1.

REFERENCE

1. Goodstein, J. R. (1970–1980). In *Dictionary of Scientific Biographies*, C. C. Gillespie, ed. (C. Scribner & Son, New York), p. 429.