

letters

tained an experimental FM transmitter located in Alpine, N.J. Following World War II, the radio industry turned to television and looked covetously at the FM band as being a spectral region that could be more usefully converted into several TV channels. The FM band was in fact incongruously relocated to its present position in the middle of the current VHF television band. An unexpected bonus (?) of this transfer is that an FM receiver can pick up the audio signal of television channel 6 at the lower end of its frequency range. (Television uses frequency modulation for the transmission of the audio signal.)

When the industry finally realized the merits of Armstrong's FM system, they sought to circumvent his patents. In February 1954, physically and emotionally drained by his ongoing court battles with RCA, Armstrong plunged to his death from his New York City apartment. One of his friends estimated that during the last years of his life, Armstrong had probably spent 90% of his time on court actions.

A sympathetic but perceptive biography of Armstrong has been written by Lawrence Lessing (Lippincott, 1956).

I appreciate the courtesy of Edmund Thelen and Catherine Earl of the Franklin Institute in making the Committee Report available to me.

Reference

1. E. H. Armstrong, Proc. I.R.E. 12, 540 (1924).

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7/27/77

Refuting relativity?

I should like to add a few comments to the recent interesting article by Beatrice Tinsley, "The cosmological constant and cosmological change" (June, page 32). My comments are only in regard to the possible role of the theory of general relativity in the cosmological problem.

A question addressed by Tinsley was: Is the universe expanding in a single outward motion of ever decreasing matter density, or will it turn around at some critical point to start a collapse inward? My main comment is that her conclusion, that the single big-bang model is most likely correct in accordance with the data, is (admittedly) model-laden, and that it is also based on a very restricted view of precisely what the theory of relativity is.

The model that Tinsley refers to (the "Friedman models") assumes a number of underlying axioms that go beyond the requirement of the theory of general relativity. These are the axioms that are generally required to derive the Robert-

son-Walker-type metric. It is assumed that the matter distribution of the universe is spatially isotropic and homogeneous (the "cosmological principle"), and restrictions are imposed on the metric that yield an absolute global time measure. That is, one assumes at the outset that the time measure from any galactic frame is the same—even though all galactic frames are accelerating relative to each other in accordance with the Hubble law. This "global time measure" is then supposed to be a measure of the evolution of the universe as a whole.

The implication of the restriction of an absolute time scale is an incompatibility with the principle of relativity. This principle generally requires that any given temporal measure, from one frame of reference, would be some prescribed alteration of the space-time measures from other relatively moving frames, in accordance with the transformation group of general relativity. The non-covariance of the absolute global time measure may also be seen from the incorporation in this model of the Hubble law, $H_0 = \dot{R}_0/R_0$ —which in itself is a non-covariant equation of motion of a star.

A tacit assumption in Tinsley's article is that the theory of general relativity is uniquely represented by Einstein's tensor equations, precisely as he wrote them. Einstein himself emphasized that "not for a moment, of course, did I doubt that this formulation was merely a makeshift in order to give the general principle of relativity a preliminary closed expression. For it was essentially not anything more than a theory of the gravitational field, which was somewhat artificially isolated from a total field of as yet unknown structure."¹

The principle of relativity is the assertion of the objectivity (covariance) of all of the laws of nature with respect to the space-time transformations between relatively (generally nonuniformly) moving reference frames. Thus, the variation of G , or the incorporation of a cosmological constant, or not, into the formalism relating to cosmology, would not invalidate Einstein's *theory*—even though it may not fit his particular (preliminary) mathematical expression of his theory—so long as the *general field equations would remain covariant*.

It follows that the only cosmological model under current consideration by astronomers that is truly compatible with the principle of general relativity is the oscillating model of a closed universe. But it must be required further that observers on different galactic frames would not agree on the *quantitative* time measure, say since the beginning of the latest expansion cycle. What it is that general relativity theory demands they agree on is the *form* of the laws of nature—thus the *qualitative* oscillating nature, expansion ↔ contraction, of the universe as a whole. I would then interpret a *conclusive*

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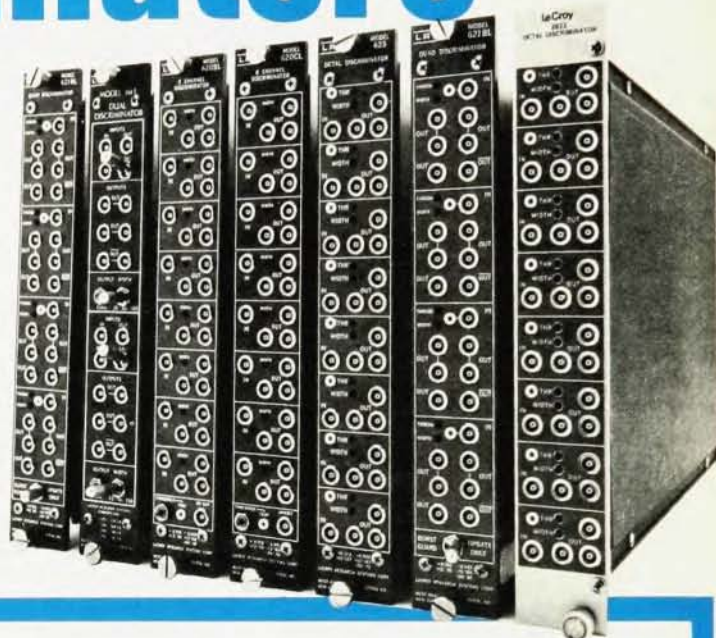
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(non-theory laden) observation of the single big-bang model cosmology as a refutation of the principle of relativity! I do not see that such an observation has ever been made.

I have discussed some of the underlying ideas of the theory of relativity in a recent book,² and I have recently demonstrated the Hubble law as a first approximation for a *bona fide* covariant equation of motion in a generalized mathematical expression of general relativity theory, where no absolute global time measure appears in the metric and where the oscillating universe cosmology is automatically incorporated.³

References

1. A. Einstein, *Autobiographical Notes*, in *Albert Einstein—Philosopher—Scientist*, Evanston, Ill. (1949), page 75.
2. M. Sachs, *Ideas of the Theory of Relativity*, Jerusalem and New York (1974).
3. M. Sachs, "The Hubble Law and the Spiral Structures of Galaxies from Equations of Motion in General Relativity," *Int. Jour. Theoret. Phys.* 14, 115 (1975).

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7/1/77

THE AUTHOR REPLIES: I disagree with Mendel Sachs's assessment that a conclusive "observation of the single-bang cosmology" (by which he means evidence that the universe will expand forever from the past big bang as in some Friedman models) would constitute "a refutation of the principle of relativity." It is possible for the laws of nature, the field equations, to be independent of the reference frame, while the solution describing the large-scale behavior of the universe has a high degree of symmetry in certain frames.

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H. G. Wells and isotopes

After working in the area of discharge isotope separation for the past two years, and thinking it to be a rather novel approach, it was with great amusement and chagrin that we read William Squire's letter (August, page 66), describing the possibility that the first discharge isotope separation experiments actually occurred in 1895. Although our comments are not meant to detract from the inventiveness of H. G. Wells, we would like to point out that based on experience in this laboratory (essentially another case of 20/20 hindsight), an isotopic interpretation of Baly's work seems improbable due to the extremely large enrichment factors required. Instead we feel that, in his dis-

charge, Baly produced ozone, which increased the measured oxygen density.

In experiments on discharge enrichment of N^{15} (*Applied Physics Letters*, 28, 372, 1976), the highest enrichments observed were less than 30%, and these were obtained only at cryogenic temperatures. At room temperatures and above, the enrichments were always negligible. In the case of deuterium enrichment in the hydrogen methane system (T. J. Manuccia and E. E. Geosling, submitted to *Appl. Phys. Lett.*) enrichment factors as large as 6 were indeed observed, but again, this was at low temperatures, and it should be pointed out that the H/D system will always show the largest isotope effects due to it having the largest $\Delta M/M$ of any pair of stable isotopes. To achieve the observation of Baly, namely an average density increase of about 1% starting from natural abundance of 0.2% an enrichment factor of over 40 would be required. This is extremely unlikely, especially at room temperatures and high (350 torr) pressures. More probably, Baly was observing the production of ozone at the 2% level in his mixture. Alternative explanations could involve impurities outgassed from his electrodes.

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8/24/77

Sexism in science

No one would disagree with A. V. Ferris-Prabhu (July, page 69) that the effort to seek out and encourage capable women is as important as the preoccupation with changing words. But I have a gut fear that the capable, independent, self-motivated woman is just the person who might object to the following:

- Papers she submits to the *Astrophysical Journal* will go out to referees with a form letter asking, "Is his work . . . , does he . . . , does his work . . . , and so on."
- Applications to NASA for position of astronaut ask for names for recommendations. Forms to these people ask, "Is he . . . , does his work . . . , and so on."
- Her work may be discussed in a national magazine under the title "Wise men from the South peer toward what may be limits of the universe," (*Smithsonian*, April 1977). At least her husband will find this funny.
- A distinguished scientist, the president of the Board of Directors of the US National Observatory, will look her (the only female) hard in the eye and call each Directors' meeting to order by firmly saying, "Gentlemen."
- She will read in an international scientific magazine (*Nature* 265, 17, Feb. 1977) an article entitled "Strategy for detection of cancer hazards to man," in

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