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Universal Cosmic Rays and Harrison's Inhomogeneity Postulate*

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ABSTRACT

Cosmologies of the type suggested by Harrison, in which initial baryon inhomogeneity leads to the formation of galaxies, are shown to preclude the possibility that cosmic rays are universal.

The postulate has recently been introduced by Harrison[1] that the distribution of baryon number density in the universe was primordially inhomogeneous over regions sufficiently large that when the temperature fell sufficiently to favor annihilation, local excesses of baryons (or anti-baryons) remained of sufficient size to condense into galaxies under the influence of gravitation. Harrison sets no explicit upper limit to the size region he wishes to develop into an all-baryon or all-anti-baryon region, but his model seems to lead to regions not much larger in mass than a galaxy, for two reasons. On one hand, it is necessary to assume the inhomogeneity, rather than derive it, and the assumption seems more radical the larger the region. On the other hand, it is intended that gravitational contraction of a typical region lead to formation of a galaxy. In fact, Harrison explicitly refers[2] to the possible existence of condensations or blobs of anti-matter within matter galaxies, and conversely. The postulate that baryon inhomogeneity leads to galactic formation seems attractive, because it requires less by way of assumed initial inhomogeneity amplitude than theories based on primordial density inhomogeneity. We therefore explore the consequences of the theory in the realm of cosmic rays.

It is an open question[3,4] as to whether cosmic rays are galactic or universal. Evidence as to the abundance of heavy elements in the distant past[5,6] could well be crucial in reaching a decision on this matter, but the presently available [6] evidence is insufficient. It is possible to show, however, that universal cosmic rays are ruled out in Harrison's cosmology. Under the universal cosmic ray hypothesis, it must be assumed that a negligable fraction[7] come from normal galaxies. Therefore the majority of cosmic rays in our galaxy would have come from other sources, and have diffused into the galaxy. The time of generation could well have been as early as 5x 10^8 y after[5] the primordial fireball. The earlier the time of generation, the more chance cosmic rays from anti-matter regions have have had to diffuse to us. But since our own galaxy must be a negligable source in a universal cosmic ray theory, it is unavoidable that cosmic rays must have diffused into our galaxy from sources at <u>least</u> as distant as the few nearest galaxies, ~ 0.5 Mpc. Now, whatever the sources of cosmic rays, in Harrison's cosmology they must produce roughly equal number of particles and anti-particles, when averaged over a few galaxies. But it has been shown experimentally that cosmic rays contain less than 0.1% antiprotons[8] and that the ratio of anti-nuclei to nuclei for $Z > 2$ is less than 0.1%[9]. Therefore, if Harrison's postulate holds, cosmic rays are of galactic origin.

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FOOTNOTES

1. E. R. Harrison, Phys. Rev. 167, 1170 (1968).

2. E. R. Harrison, Phys. Today 21, 31 (1968).

3. R. J. Gould, Am. J. Phys. 35, 376 (1967).

4. V. L. Ginzburg and S. I. Syrovatskii, The Origin of Cosmic Rays, The Macmillan Co., New York, 1964. See especially p. 282 and the note on p. 277.

5. Ibid, p. 259.

6. P. B. Price, R. S. Rajan, and A. S. Tamhane, Astrophys. J. (Letters) 151, L109 (1968), and other references cited therein.

7. Ref. 4, p. 264.

8. H. Aizu, Y. Fujimoto, S. Hasegawa, M. Koshiba, I. Mito, J. Nishimura, K. Yokoi, and M. Schein, Phys. Rev. 121, 1206 (1961).

9. N. L. Grigorev, D. A. Zhuravlev, M. A. Kondrateva, I. D. Rappaport, and I. A. Savenko, Zh. Ezperim. i Teor. Fiz. 45, 394 (1964) [English transl.: Soviet Phys. -- JETP 18, 272 (1964).]